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ABSTRACT

An overview of research in educational communications and technology is provided as it applies to science education in intermediate/middle school grades 6-9. The overview is divided into five chapters focusing on: (1) educational television; (2) film; (3) audio; (4) programmed learning; and (5) visual. The major thrust of the review is to identify the most effective use of each of the five areas for science education as well as advantages and limitations. Each chapter reviews the research literature, provides a number of abstracts exemplifying the findings, and includes a summary, conclusions, and bibliography. It is suggested that the most effective use of media for science education appears to be combinations of all types with traditional science instruction, thus providing students with a variety of learning modes. (Author/JN)

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EDUCATIONAL COMMUNICATIONS AND TECHNOLOGY AS APPLIED TO SCIENCE EDUCATION IN INTERMEDIATE/MIDDLE SCHOOL

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PREFACE

This paper provides an overview of the research in educational communications and technology as it applies to science education in intermediate/middle school (grades 6-9). It has been prepared as part of the research interest of the author who is a member of the staff of the Curriculum Research and Development Group.

This overview is divided into five sections or chapters, Educational Television (ETV), Film, Audio, Programmed Learning, and Visual. Each extensively reviews the research literature in the particular area and provides a number of abstracts exemplifying the findings for each type of media as it applies to science education at the middle school level. A summary of the research review is also provided in each chapter as well as the overall conclusions of this reviewer.

The various types of media are all used in science instruction. As will become evident in this review each has its own particular advantages and limitations. A skillful and knowledgeable teacher will be able to choose the most appropriate medium for the subject matter to be transmitted and for the students who are to receive instruction. The most effective use of media for science instruction seems to be combinations of all types of media with traditional science instruction, thus providing students with a variety of learning modes. It is the purpose of this research review to identify the most effective use of each of the five areas of educational communications media for science instruction.

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Chapter 1

ETV

EDUCATIONAL COMMUNICATIONS AND TECHNOLOGY AS APPLIED TO SCIENCE EDUCATION IN INTERMEDIATE/MIDDLE SCHOOL

ETV

INTRODUCTION

During the past thirty years there has been a great deal of controversy over the use of television in education. Some have shown that highly significant results can be obtained using this media, while others have shown the opposite or mixed results. Schools and administrators have been reluctant for the most part to use television on a wide scale. Some have made token uses while others have avoided it entirely and still others have tried it and given up. Just how has television been used in the science classroom and with what results?

DEFINITION OF TERMS

There are certain terms connected with television usage which require clarification. Unfortunately, those dealing with the medium have not been careful in their usage of terms resulting in a confusion in the literature.

Educational Television (ETV) - is a broad term usually applied to cultural and community broadcasting which may or may not include some programs for in-school use.

Instructional Television (ITV) - is television used in the formal classroom at any educational level. Confusion in the literature has arisen from the use of ETV to cover all types of educational broadcasting including ITV. Writers often use these terms interchangeably.

Closed Circuit Television (CCTV) - refers to the use of television transmitted from cameras to receivers over a cable or by microwave permitting reception of programs only by those receivers included in the circuit. This type of set-up is most commonly used in science laboratories for demonstrations.

Video Tape Recorder (VTR) - records on magnetic tape like an audio tape recorder. VTR's are available in several modes from reel to reel to cassettes of various types.

The remainder of this paper will use abbreviations consistent with use by the authors of the various researches cited.

TELEVISION USES

Television can be used in a variety of ways in education. It can be a CCTV system in a single room used to enlarge demonstrations for laboratory or lecture. In this manner it becomes a valuable teaching aid. It can also be used as a conventional ITV from studio to classroom to aid the teacher in schools where there is a shortage of qualified teachers. For elementary schools this is particularly relevant in science.

As shown by Schramm (1962) ITV is better suited to some subjects than to others and seems best suited to science instruction. The camera can follow complex experiments and demonstrations with accuracy and magnification. In addition, the TV can bring the scientist into the classroom (Draper 1953).

The television is no substitute for doing science, but it can provide initial or supplementary information for subsequent laboratory work. The value of TV as a magnification device has been cited by many writers (Richter 1964, Eanet & Toth 1976; and others).

The remainder of this paper will present research studies on the use of TV relevant to science instruction at the intermediate or middle school level (grades 5-9). Some studies at both the lower elementary and upper secondary levels have also been included because of their direct relevance to the target population.

SURVEYS

The results of research on ITV are conflicting. In an effort to provide a meaningful summary, Schramm (1962) surveyed 393 research papers with adequate design, controls, and statistical treatment to be deemed valid. Many were papers that had not appeared in journals, but were well done. The reports dealt with the use of ITV versus classroom instruction for all subject areas in kindergarten through college. He eliminated all studies not designed with matched groups and a pre- and posttest of achievement. In 65% of the studies no significant differences were found between the groups; in 14% students learned significantly less from television; and in 21% they learned significantly more by television than in the regular classroom. The conclusions reached by Schramm were:

1. The average student is likely to learn about as much from a television course as from ordinary classroom methods.
2. Television instruction in math and science is very successful, while in history, humanities, and language it is somewhat less successful.

Stickell (1963) attempted to clarify the contradictory results from 250 comparisons of ITV and classroom instruction. Stickell set rigorous standards for good experimental design based on his own modification of analysis of designs found in the Handbook of Research on Teaching. Of the 250 studies, 217 were classified as "uninterpretable", 23 "partially interpretable" and 10 were found to be "interpretable." There were no contradictory results reported in the ten remaining studies. All showed no significant differences between the effects of ITV and classroom instruction as measured by the paper and pencil tests used. All ten were at the collegiate level.

Garry (1960) had done an earlier survey on uses of television in the United States. His conclusions were similar, that ITV is at least as effective as regular classroom instruction and on occasion is more effective and retained at least as well. Garry also pointed out that television is flexible in meeting the needs of large classes by making better utilization of good instructors and in showing close-ups of small objects used for demonstrations.

STUDIES FAVORING TELEVISION OVER CLASSROOM INSTRUCTION

The surveys done by Schramm and particularly by Stickell set stringent standards for selection of reliable studies. Though this is a sound practice for interpretation of research data it eliminates relatively good studies which may serve as indicators of effectiveness even though they suffer from weak research designs or lack of control of intervening variables. The following 11 studies have been found to statistically favor the use of ITV over regular classroom instruction.

> Champa (1957) tested the effects of ETV and films on achievement in and attitudes toward science of ninth grade students in Lancaster, Pa. Three hundred students of comparable ability were divided into 3 groups for a one year course in science. Group 1 (control) received conventional science instruction. Groups 2 and 3 received the same course but Group 2 had thirty minutes of ETV including films and resource people each week, while Group 3 had thirty minutes of the same ETV films. Pre-Post tests, the Cooperative General Science Test (achievement), the Kuder Preference Record (attitudes), and a survey of science related activities were administered. Significant differences in achievement ($p < .05$) for all three groups were found. Use of films was significantly greater than the use of ETV. The use of ETV was significantly greater than the regular classroom instruction. Findings were similar for both males and females. Pupils preferred films and ETV almost unanimously over conventional science instruction. One year after the experiment a greater proportion of pupils in the film group were pursuing more science than had been the case in previous classes.

Champa's results though impressive and suggestive of greater use of film and ETV in teaching science must be interpreted with caution in terms of their applicability in the 1980's. His work was done in 1956 before the advent of inquiry and laboratory science courses. It can be assumed that the "regular classroom instruction" consisted of lecture with heavy emphasis on the textbook. It could be inferred that students were more motivated and attentive to the new television technology of the late 1950's than would be the case today.

> Jacobs and Bollenbacker (1959) evaluated the effectiveness of ITV and regular classroom instruction on science achievement of 315 sixth grade students in Cincinnatti. Median IQ's from all elementary schools in the public school system were ranked, then divided into 3 ability groups, high, medium and low. Within each ability grouping 2 pairs of schools were selected, one pair assigned to TV instruction, the other pair to conventional classroom instruction. A standardized pretest in science was given to allow statistical adjustment between groups for beginning science knowledge. A criterion referenced posttest was locally developed and validated. Results showed that the TV group exceeded ($p < .05$) the classroom group at the high ability level. There was no significant differences at the middle or low ability levels.

Stovall (1960) conducted an experiment with television effectiveness on teaching secondary school physics in Houston schools. Twenty nine independent school districts and 53 classes participated in the study. Comparison of television classes with conventional classes showed significant differences ($p < .05$) favoring the television group. In addition Stovall found that there was a favorable attitude of teachers toward ITV, that there was no significant difference in student gain by matched pairs due to level of school district expenditure, quality of laboratory facilities, class size, quality and amount of teacher training, student prerequisites in science, or student ability level.

Jacobs and Bollenbacker and Stovall present conflicting evidence on the effectiveness of ITV on various ability groupings. As shall be seen in later references this is consistent in the research literature.

Garry (1960) tested the effects of various uses of ETV on 90 classes of fifth graders in Boston. Eighteen control classes used 30 half hour natural science ETV programs without accompanying classroom activities. Thirty six classes used the programs as a terminal activity. Thirty six classes used the programs to initiate related activities. In each group one third of the teachers were trained in a science workshop, one third were trained to use ETV in class, and one third received no special training. Achievement gains on a project developed test were significant ($p < .05$) for experimentals over controls. Differences between experimental groups were not significant. Observed effects on science reasoning, interest, and attitudes were reported as negligible. Type of training for teachers did not have a significant impact on student performance in any of the groups.

Garry's data suggests that ETV can be effective for all ability students at least at the middle school level. It is interesting to note that training of teachers did not have significant effects. This could be due to the reluctance of teachers to change established patterns of behavior or possibly to an ineffective training package.

House (1964) studied the effect of ITV as an aid in third, fourth and fifth grade science instruction. Sample population consisted of 170 girls and 163 boys studied over a 3 year period. In the third grade the sample was divided into television and control groups. The control received science instruction in self-contained classrooms and no ETV. The television group received science instruction via ETV. All students received ETV science instruction when they reached fourth grade. In the fifth grade the groups were again divided, one group received ETV science instruction in self contained classrooms while the other group received ETV science instruction in large resource rooms. IQ measures were used to classify the sample into high, medium and low ability levels. Reading test scores were used to group the sample into good and poor readers. The Metropolitan Achievement Test - Science was used as a criterion measure. House reported that good readers did better than poor readers, third grade students did better with ETV than conventional instruction, boys profited more from ETV than did girls, administering tests over ETV aided poor readers, and students in large resource rooms do as well as students in self contained classrooms.

House's research must be approached with caution. He obviously has introduced too many intervening variables making it difficult to draw any valid conclusions regarding ETV versus conventional instruction. What is important to note about the study is the possible differences in achievement using ETV due to reading ability and sex indicating that individual differences in students may determine when and if ETV is an appropriate medium for instruction.

> Welliver (1965) compared the effectiveness of television and non-television in ninth grade physical science in North Carolina. Twenty four classes in two school districts were randomly divided into ITV and non-ITV groups. The Otis Quick Scoring Mental Ability Test was used as a pretest. The General Test of Course Objectives constructed by the experimenter was used as measure of beginning science knowledge. Posttests after one year of instruction consisted of the Physical Science Achievement Test constructed by the experimenter, the Test on Understanding Science (TOUS), the Science Current Events Test constructed by the experimenter, the Sequential Test of Educational Progress - Science (STEP), and the Thurston Interest Inventory. Results showed statistically significant differences ($p < .05$) favoring the ETV group of above average ability. Analysis of scores for students of average ability favored the non-ITV group. Analysis of scores of the low ability group favored the ITV instruction. Welliver concluded that ITV is more effective than non-ITV with students of above average and low ability benifiting more from ITV instruction than from non-ITV instruction. The two methods were found to be essentially equivalent for teaching science to students of average ability.

Again the question of effectiveness of ITV for students of different ability levels is conflicting. It seems increasingly clear that ITV does not have equivalent effects for students of all abilities.

> Gorth et. al. (1968) investigated the effectiveness of lecture on videotape versus live on a sample of 900 eighth and ninth graders. Videotaped lectures and live lectures were presented on science and social studies units. Groups receiving good quality videotaped lectures achieved significantly higher ($p < .05$) means than those receiving live lectures. High ability groups were significantly higher ($p < .02$) than low ability groups. Gorth concludes that repetition of good quality videotaped lecture provides a more stable and sensitive measure of effectiveness and enhances student achievement.

> Beets (1968) studied the effectiveness of ITV for teaching creative thinking to fifth and sixth graders. The inquiry method was used as well as involvement of students in the live telecasts. 420 students were randomly selected and divided into 4 groups. 1) Pilot - which was

used to standardize scores of the other groups. 2) Experimental - students viewed ITV and during three of the telecasts had a direct phone line to the studio. 3) Experimental - students saw the telecasts but did not participate further. 4) Control - not ITV. All students were given Creative Thinking pretests. The same test was given as a posttest. Results showed significant differences ($p < .01$) between groups 2 and 3, 2 and 4, 3 and 4. It was concluded that using the inquiry method of instruction via television did make a positive, significant difference in student's creative thinking abilities.

This is a particularly interesting finding since inquiry in science instruction has been thought to require hands-on activities for students prior to and during the development of concepts. This assumption has been the basis of the development of most of the major curricula in science for elementary and intermediate school populations over the last 20 years.

Moore (1969) conducted an experiment involving CCTV and programmed learning. TV classes were taught by lecture/recitation while the programmed sections were taught using a variety of resources to augment the programmed text. Pre- and posttests were given to both groups. After adjusting for individual differences analysis of covariance showed that the TV group produced a significant positive difference on student attitudes compared to the programmed group as well as a significantly greater mean achievement score.

Radlick and O'Reilly (1976) involved 901 students from nine school districts and 301 control students from the same districts in a program to test the effects of ITV. Experimental students received TV instruction for two hours a day for 20 days. The control students received regular classroom instruction. Results indicate that ITV is best adapted to teaching science, health, social studies, and consumerism to fourth graders.

Radlick and O'Reilly support the conclusion reached by Schramm (1962). In summary, these eleven studies have demonstrated that ETV can result in significant gains in achievement in science, however, other variables must be considered, particularly student ability levels

STUDIES FAVORING CLASSROOM INSTRUCTION OVER ETV

Not all research reports support the effectiveness of ETV over classroom instruction. The following studies show the opposite effects.

Thornton (1970) investigated 1) the relative effectiveness of ETV and programmed instruction, 2) the effectiveness of using both media to supplement and reinforce each other, 3) the effectiveness of ETV and programmed instruction compared with tradtional classroom teaching, 4) the best sequence of using the 2 media, 5) the effectiveness of using

> programmed instruction to check the progress of ETV students, and 6) programmed instruction's role in counteracting the noninvolvement of ETV students. 452 sixth grade students were divided into 7 groups, 1) only programmed instruction, 2) ETV only, 3) traditional classroom teaching, 4) programmed instruction followed by ETV, 5) ETV followed by programmed instruction, 6) combination of traditional teaching, programmed instruction, and ETV, and 7) no science instruction. A pre- and post test science test was administered. Results showed that ETV produced no greater student achievement than a combination of methods or no science instruction, ETV produced signifcantly lower student achievement than traditional classroom instruction, and traditional classroom instruction produced significantly higher student achievement than ETV used alone, programmed instruction used alone, a combination of programmed instruction followed by ETV, or no science instruction.
>
> Galey and George (1974) studied the effect of ITV on development of classification skills in first graders in a New Jersey public school chosen at random within the school district. Six TV lessons were prepared with one of the experimenters as the TV teacher. Treatments were randomly assigned to five classes. 1) TV with introductory and follow-up activities by the experimenter, 2) TV with free choice of activity after viewing, 3) No TV - same lessons taught by the experimenter 4) No TV - teacher conducted similar lessons using SCIS materials, and 5) control - no ITV and no science. Total number of students was 123. A pre/post test performance interview test was given to all students. One way Anocovar analysis of posttest adjusted means showed no significant differences between groups 1 and 2, 1 and 3, or 3 and 4. Significant differences were found between groups 1 and 4 ($p < .05$), 2 and 3 ($p < .05$), and 2 and 4 ($p < .01$). All experimental groups were statistically significantly superior to the control group ($p < .01$). Experimenters concluded that the classroom lesson, group 4, was more effective than the ETV lessons.

Both these studies show that classroom instruction is superior to ETV or even programmed instruction. Even though the Galey and George study questionably assumes that first graders can indeed learn classification skills with such short exposure it still strongly supports traditional classroom instruction resulting in greater achievement. There seem to be fewer of these studies in the research literature than those that show the superiority of ETV. What is most commonly found however, are studies showing no significant differences between the two. This is the subject of the following section.

STUDIES SHOWING NO SIGNIFICANT DIFFERENCES

Much more commonly research studies on the effectiveness of ETV tend to show no significant differences between ETV and conventional classroom teaching. The following eleven studies serve to illustrate this point.

> Daniels (1959) investigated four groups of students of "apparently similar ability" and their achievement in secondary science after differing modes of instruction. Group 1 had TV only, Group 2 had the sound track of the TV programs only, Group 3 recieved conventional science instruction, and Group 4 received no science instruction at all. Daniels concluded 1) there was no significant difference to indicate that any of the three methods was superior and 2) some teaching is better than no teaching. All three treatment groups were statistically significantly better than the control group.

On the surface, Daniels seems to indicate that though student ability may enter into the analysis, there does not seem to be any significant difference between TV instruction and regular classroom instruction. This study did not attempt to evaluate the ability level of the students involved. Daniels' statement that the students were of "apparently similar ability" may well be true. but if they were of middle or average ability these results then are consistent with those of Jacobs and Bollenbacker (1959) and others.

> Enders (1960) investigated the achievement resulting from using ETV as a supplementary aid to teaching science at sixth grade level. For 20 weeks students received 15 minute planned ETV science programs related to the science unit being taught in the classroom. Another group viewed 12 ETV lessons while a third group viewed no ETV lessons. Results showed no significant differences between the groups.

> Syrocki and Wallin (1962) conducted a two-year study in human biology. Two lecture demonstrations per week were given to multiple sections of sophomore college students. Half were given conventional instruction, half ETV instruction. Models, demonstrations, etc. were kept constant in both groups. Contents of lectures were as identical as possible. All students received a pre- and posttest. Results showed 1) no significant differences between mean scores of both groups, 2) no significant differences between mean gain scores.

Though the Syrocki and Wallin study was drawn from beyond the target population of this study their conclusions that ETV can be satisfactorily used to teach human biology seems to be well supported. Tannenbaum (1956) found that achievement of students taught biology by ETV was as great or greater than those taught conventionally. Similar results were found by Siebert (1958) for physics and by Greenhill (1959) for zoology.

Garry (1963) tested the effect of 2 types of TV programs - information giving and problem solving on 36 classes (1000 students) of fifth grade students in Boston. Subjects were selected on the basis of teachers who had participated in a previous study on teaching natural science by ETV. Selection procedures attempted to hold teacher variables constant by selecting "average" teachers. Classes were divided into 3 groups of 12 each. Teachers in group 1 (control) were not trained. Teachers in groups 2 and 3 were trained to use ETV to provide information and to stimulate problem solving respectively. Group 2 viewed 20 ETV programs used in a previous study. Group 3 viewed 10 "old" programs and 10 new programs. There were no significant differences in science achievement. Retention was not significantly different between groups.

Jerkins (1964) investigated the effect of a television course in science on 1,908 seventh, eighth, and ninth grade students. Half the classes received TV instruction, half received regular classroom instruction. Three achievement tests were given and two questionaires. No significant differences were reported between the TV and non-TV groups.

Bickel (1964) studied the achievement and attitudes of students in grades 4, 5, and 6 receiving science instruction via CCTV incorporating a talkback facility and students taught science in the regular classroom. One TV and one control classroom were selected at each of 3 grade levels resulting in nine pairs of classes. Achievement measures included the Stanford Achievement Test - Science administered in classrooms and the California Elementary School Science Attitude Test administered to all classes via TV. No overall statistically significant differences were found between treatment and control groups in achievement. Similarly, there were no significant differences between groups in attitudes toward science.

Bickel's data appears to indicate that at least on some instances even the addition of a talkback facility does not necessarily enhance student achievement when using ETV over regular classroom instruction. Several proponents of ETV have indicated that such a mechanism would significantly improve ETV use in schools.

Skinner (1967) investigated ETV and the use of inquiry in science instruction. 123 students were divided into 4 groups. 2 groups received inquiry science lessons via ETV. A third groupd received inquiry instruction by the experimenter, while a fourth group received science instruction from the regular classroom teacher. Results showed that inquiry teaching was as effective as television in presenting science lessons. Further, student designed follow-up activities for the ETV lessons were as effective as teacher designed pre and post lesson activities.

Galey (1970) studied 123 first grade students and the effects of ETV. Five treatment groups were established: 1) TV with pre- and post lessons, 2) TV with no introductory lessons, 3) No TV - class taught by Galey, 4) Control - regular science instruction, 5) No TV - class taught by regular classroom teacher. Performance interview pre- and posttest were administered. Results showed no significant differences between TV and no TV classes taught by the experimenter. There were significant differences between TV classes and classes taught by the regular classroom teacher. The study concluded that ETV and classroom instruction were equally effective in improving student achievement in science.

Poteet (1972) studied 47 seventh graders to determine the effects of viewing a series of "Mr. Wizard" programs. Students were randomly divided into 3 groups. Group 1 viewed 12 "Mr. Wizard" programs. Group 2 also viewed the programs and were interviewed. Group 3, the control saw a series of films unrelated to science. The tape recorded interviews were evaluated independently by 3 evaluators. Results showed a significant difference between experimenatals and controls in preferences for science, no significant differences among the 3 groups in achievement, and no overall significant correlations between preferences and achievement.

Kohlmeyer (1974) selected a quasi experimental design involving 203 students in grades 4 - 6 to determine the effects of ITV on low achieving students. The subjects had been designated as below grade level in achievement. They were assigned to three treatment groups. All groups viewed a twenty minute TV science lesson. The control group had an open circuit TV and pre-post lessons reinforced activities presented by TV. Another group had open circuit TV and indvidualized learning packets for reinforcement of pre-lesson and post-lesson activities. The third group viewed the TV lesson individually on VTR and had the individualized packets. All groups were administered a pre-post achievement test to establish gain scores. There were no significant differences in learning resulting from any of the treatments.

In summary, one could look at the research showing no significant results as a failing on the part of ETV. On the other hand, these results should be interpreted more optimistically. That is, ETV is as good as, and in some cases better than conventional classroom teaching, particularly with higher ability groups.

OTHER FACTORS AFFECTING THE USE OF ETV

Several other studies have identified variables that affect the use of ETV in science instruction in addition to student ability which has already been discussed. Some of these factors are presented in this section.

Wade, (1969) studied 817 fifth grade students in Santa Clara County and the effect of ITV and various teaching methods. Three methods socratic (active teacher questioning and correction of student response), teacher

> tell (iteration of TV content), and control (general peripheral motivational activities). The TV unit was a six-week, 12 lesson series on insects and animals. Results showed that the socratic method had significantly greater mean scores than either of the other two methods ($p < .01$). There was no significant difference between teacher tell and control methods. Low ability students tended to make better gains in control groups, while socratic methods tended to favor high ability students.

Studies such as this seem to suggest not only is the ability level of students using ETV important, but also the instructional strategies used by the teacher. Socratic or inquiry methods tend to cause students to think more about what they have viewed on TV, to process information presented and to apply it in novel situations. Such methods may indeed significantly increase the effectiveness of ETV by changing the student focus from one of absorbing information given to actively using information to develop deeper understandings of concepts.

> Reich and Meisner (1972) investigated the effectiveness of color versus black and white television concentrating on factual retention of subject matter. Researchers tested 12 seventh grade classes in Toronto schools. They found little evidence that color was a different instructional medium than black and white. Data suggests that color may reduce value of the spoken word, making color a valuable medium only when material to be taught involves visual experience or a dramatic event.

> Schramm (1971) surveyed 120 research studies on the content and strategies of ITV. He concludes that color seems not to increase learning unless color is what is to be learned. A large screen seems to be of little or no advantage over an ordinary screen. Students like a talkback system but seem to learn no more when it is present. There seems to be no advantage for existing three dimensional projection. Eye contact seems to contribute to learning. In general, two useful guidelines emerge, simplicity of presentation and active student participation.

It is interesting to note in these studies that in times of emerging technology capable of colorful graphics and displays that black and white imagery may be just as effective except in cases where color is the message. It may well be that color detracts from both the verbal and pictorial message being presented. Schramm's conclusion about feedback is not shared by other researchers.

In the course of experimentation with television over the past years several different approaches to instruction have been tried. These can be classified into two broad categories, information giving and problem solving. Problem solving includes the discovery approach and therefore programmed instruction.

> Gropper and Lumsdaine (1961) did a series of experiments employing the best research techniques available at the time on programmed instruction using television. They constructed a series of TV lessons which progressed in small incremental steps and included good feedback and contrasted this approach with a conventional TV lesson. They concluded that it is difficult and not feasible to develop programmed TV lessons for group instruction when there are wide differences in ability levels. Programs must be extremely well devised to lead students to the correct response, otherwise wrong information may become fixed.

Garry (1963) did a similar study and concluded there was no significant difference between programmed and ETV instruction.

> Zettl (1967) attempted to classify various kinds of feedback systems used in television programming. The following is his categorization:
>
> A. Direct feedback - the viewer reacts directly to the originator. This is further broken down into immediate and delayed feedback.
>
> B. Indirect feedback - the viewer does not react to the teleteacher until the end of the lesson. Most common form is letter writing. Indirect immediate feedback occurs when the viewer can observe a studio class react. Indirect delayed feedback occurs when the teleteacher asks the viewers to engage in specific activities following the lesson.
>
> C. Displaced feedback - the reaction of viewers takes place independently for instance a discussion among the viewers after the telelesson.

A considerable amount of research has been done on the usefulness of the various feedback systems. Bryan (1961) did an extensive evaluation of chemistry and physics courses taught by television with and without feedback. He concluded that for physics there was no significant difference between treatments, but for chemisty ETV plus direct and displaced feedback was significantly more effective than either alone.

> Wolgamuth (1961) did a study comparing the effectiveness of three feedback techniques; TV only, TV plus direct immediate feedback, TV plus indirect feedback, and TV plus electical feedback devises. 80 students were assigned at random to treatments. Pre- and posttests

were given to measure achievement. Results showed no significant differences among the methods indicating that feedback had no effect on learning.

Kumata (1960) did a survey of ten years of research on television teaching and concluded that there was no significant difference between television and classroom teaching in information gain, retention, and feedback. More surprisingly he concluded that feedback macharisms are not a substitute for interaction, but their presence gives students reassurance. When they are present, such mechanisms are seldom used by students, however, students feel more at ease when they are present. The best results in information gain are obtained when a discussion is held after a TV lesson by a competent teacher.

It would appear then that the use of programmed instruction be left to the individual teaching machines and that for TV we should rely on a well constructed, information giving technique. Individual differences are too vast to be treated in the same manner. Attempting group instruction by programmed television may lose too many students and, if so, is not desireable. In regard to feedback mechanisms, students seldom use them when they are available and there seems to be no significant difference in achievement when they are not present.

Finally, there are indications that ETV may have effects not only on students, but also on teacher behaviors.

Yeoh (1973) systematically observed 15 teachers and their intact classes of sixth, seventh and eighth grade students in San Francisco as they used a series of ETV science lessons. Conclusions drawn from the results of how teachers supplemented the presentation indicated that the extent to which the TV broadcast matched the class schedule determined whether or not the pre-teach and/or follow-up instruction was included. Further, teachers exerted considerable direct influence on students verbal behavior. There was strong indication that student success on the criterion test administered was a function of the teacher's skill in questioning and directing and reinforcing appropriate student cognitive processes. Yeoh also noted that students indicate that they have realistic and pedagogically sound suggestions about the ways ITV is used.

SUMMARY

From the past research done on the uses of ETV there are obviously some functions which it can perform effectively and others at which its effectiveness is less clear. In reviewing the research several points have been brought out:

1. Whether students are taught by television or by regular classroom instruction achievement follows the usual pattern of those with higher ability learning more than those of lower ability, i.e., good students will learn regardless of the manner in which they are instructed.
2. The subject in which television is used is a determining factor in whether or not it will be effective. Television seems best suited for instruction in the sciences.
3. A television lesson should be followed by a session with the classroom teacher in some sort of follow-up activities and/or discussion.
4. Television is more readily accepted by elementary students and adults than by high school or college students.
5. Retention is a questionable aspect of ITV, however, information delivered over television appears to be retained at least as well as that delivered in the conventional classroom.
6. Television has several advantages useful in science education:
    a. Magnification of demonstrations and visual aids can give everyone a good view of what is being presented.
    b. Resources and authorities can be brought into the classroom which would not otherwise be possible.
    c. Compensation can be made for weak areas in teacher background. This is especially important in the elementary school.
    d. Lessons on TV are generally better prepared and more precise than those presented in the regular classroom.
    e. Equivalent or greater gains in achievement are accomplished using ETV.

7. Television also has several limitations:
   a. Teachers often lack abilities necessary to teach effectively using TV.
   b. TV exposes teacher weaknesses making some teachers afraid of teaching via the media.
   c. There is no face-to-face contact with students to check understanding as the lesson proceeds.

CONCLUSION

With its power to extend teaching, its power to record and store events, its power to bring the world of science into the classroom ETV is an exceptional adjunct to the classroom teacher. In some instances, particularly with high ability students TV can be used as the medium of instruction in intermediate/middle school. It is clear that used for instructional purposes ETV can be as effective as regular classroom teaching at least for short term student exposures. Its most effective use appears to be with the classroom teacher actively involving students in follow-up activities and/or discussion to cause students to synthesize and apply information presented via TV and thereby develop a more thorough understanding of it. Students can not be considered inactive absorbers of information. In science the ability to TV to magnify, show detail, introduce scientists into the classroom, show demonstrations that would otherwise be infeasible and in general support the instructional process makes it a valuable asset to education.

However, despite the past 30 years of research on ETV and the complimentary verbal and written conclusions regarding its usefulness in science it is a fact that ETV is not significantly used in science education at any level. This can perhaps be explained from a number of perspectives. First, ETV is still relatively expensive to use. Aside from the purchase of equipment such as monitors and VTR's there is the additional expense of operating studios, producing quality programs, and scheduling their use. Such operations have so far been taken over by professional corporations which may or may not have any insights into educational systems and needs of classroom teachers.

Second and perhaps most importantly, teachers are not familiar with the uses of the media. They have not been adequately trained in their preservice preparation. There are no school or inservice programs generally available for teachers to become familiar with ETV and its advantages. There are costs involved in such inservice programs as well. In times of increasing demands on education dollars it is not likely that this situation will soon change. It seems clear that until some impetus for training teachers in the uses of ETV are provided it will remain for the most part the subject of educational research rather than of educational use.

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Chapter 2

FILM

FILM

INTRODUCTION

Film is probably far more commonly used by science teachers than ETV at the present time. Film can be an integral and essential part of the science classroom since it is able to bring to students experiences, places, resources, and individuals to which they would otherwise not have access. Films are most often used to show an experiment requiring special materials or substances which could not be performed by students, to show unusual phenomena, organisms, ecosystems, etc., to show scientists at work, and to show events in either reduced or expanded time frames so that events that would otherwise not be observable by students can be shown.

Film as used in this chapter includes several differing formats. These are:

1. 16 mm films - by far the most common form of large group instruction used in science education (Brown 1977).
2. 8 mm films and Super 8 mm film - the most recent innovation in film are available in open reel or continuous loop. Though most are silent newer technologies provide sound track as well. The film loop cartridges require no complex threading making them ideal for individual instruction (Brown 1977; Wittich & Schuller 1979).
3. Videotape - often referred to in the literature either with film or considered synonymous with film. Videotape provides motion and sound usually in cartridge form making them increasingly appealing to schools. Videotape is not dealt with in this section. See Chapter 1 for an overview of research on videotape.

4. Filmstrips - low cost filmstrips usually accompanied by audio tape are prolific in science education. Like film, filmstrips can bring visual information into the classroom that otherwise would not be available.
5. Slides - considered along with filmstrips to be still projection of film, slides have several advantages. They may be rearranged to emphasize different points, deleted, added to and in short are more flexible that other types of film (Brown 1977).

The majority of the films used are of the expository type regardless of format. There has been comparatively little change during the past forty years of science film production though there seems to be increasing use of some of the present day sophistication in the technology such as animation, fade-in, fade-out, wipe, close-up, dissolve, etc. Both scene lengths and total film length are longer in recent films (Razum 1972).

Research shows, however, that science teachers have difficulty making effective use of film because of unsatisfactory subject matter, quality of script, quality of production, obsolescence, vocabulary difficulty, and advertising. Barnard (1956) reviewed 24 science films and reported 44% served no unique function and contributed to none of the objectives of science in secondary school. In a review of filmstrips, less than half the frames made any contribution to science content, methods, or attitudes.

Wittich and Schuller (1979) report reviewing the research on the use of filmstrips and still projection and conclude that it is an effective means of communicating factual information and certain skills; that combining still projection with other methods of instruction is likely to produce the most efficient learning; that still projection materials must be selected and used carefully if they are to be effective. In regard to films research shows that film can be effective if students are properly prepared for viewing. Wittich and Schuller conclude that film is likely to result in greater student learning when:

"1. Students know how the content of the films is related to the subjects they are studying...
2. Students know the specific reason they are being shown the film.
3. Students know what, exactly, they are expected to learn from the films.
4. Students understand that the films are learning experiences..."

RESEARCH ON THE EFFECT OF FILMS ON STUDENT ACHIEVEMENT

The following fourteen studies deal with the effect of film on student achievement in science.

> Barnard (1956) reviewed the research on instructional methods and materials utilization in science. He concluded that if teachers were not sure of the quality or content of the media they should not gamble with class time. Carefully selected films have educational value. Sound, 16 mm films were found as effective as teacher demonstrations in science. Some films can present concepts not taught by other methods. Where films are effective there was careful planning for student preparation and follow-up.

This early study makes the same conclusions and recommendations as Wittich and Schuller in regard to use of film in the classroom regardless of subject area.

> Hubbell (1957) compared filmstrips, student activities, and science text effectiveness on eighth grade student achievement. A subsidiary purpose of the study was to correlate scores on a standardized test of primary mental abilities with respect to gains in information obtained through the three instructional techniques. A rotation plan was utilized to have a different method of instruction in each unit of the study. At the completion of a unit (three units of science were used) each of the three sections was given a final unit test. At the end of the study the three tests were administered again in the form of a retest. An interest inventory was also administered. The filmstrip was presented exclusively with no other demonstrations. The text was a basic text used as a source of information for the three units. The student activities treatment involved students in lab and simulations designed to teach the concepts in the three units. The activity method and the filmstrip were more effective than the text in providing for student achievement for eighth grade students. The filmstrip and activity treatments showed no significant differences in student achievement irrespective of the differences existing among students in mental abilities.

> Hall, Johnson, and Vandermeer (1964) compared the effects on learning achieved from 1) existing commercial filmstrips combining visuals with printed captions, and 2) similar filmstrips covering the same content, but presented in small, previously tested segments with active response required of the students. Also attempts were made to study the effects of group and individual pacing and measure effects of confirmation of response to questions asked during presentation and compare the results with results from presentation with no confirmation in group presentations. The captions were read both visually and orally, but in individual study the students had no oral presentation. The study was made with students ingrades 5, 7, 11, and

> 12. Results indicated that in all grades the programmed presentation produced better posttest scores. At fifth grade level programmed filmstrips with confirmation in a group presentation showed significantly different posttest scores in achievement than individual self paced instruction. At seventh grade programmed filmstrips were more effective than nonprogrammed filmstrips. At eleventh and twelfth grades results were similar to seventh. No conclusions could be drawn concerning relative effectiveness of individual presentation and pacing or of group presentation and pacing. No significant differences were found that would verify effectiveness of confirmation.

Both these studies demonstrate that filmstrips can be an effective means of instruction in secondary science. Questions of adjustments or additions to the film or filmstrip such as pacing are the subject of a later section of this overview.

> Wittich and others (1967) designed a program to develop and teach a high school physics course via film consisting of 162 daily half hour lessons via television. A complete 16 mm sound motion picture of the lesson was available thus bringing the two media into interplay. The resulting films were labeled tele-films or T-films. Following the viewing of the first films planning was initiated to evaluate the physics study situations. Control (782 students) and experimental (550 students) were set up. Physics teachers agreed that the films offered excellent laboratory demonstrations and experiments not possible in the ordinary high school laboratory and that the content of the films was excellent. Data was collected by questionaire on feelings toward the films. Achievement of students in physics was compared. Many teachers disapproved of giving up almost all of their class time to the films. Others felt that a film a day did not provide enough variety or flexibility in the program. Students felt that the demonstrations were excellent, but that the pace was too fast, the mathematics too advanced, and that they had no time in school for practice or experimental work. Control students expressed a higher interest in science that the T-film students and anticipated going to science class more. Intelligence had a positive influence on students' interest in science, the higher the intelligence, the more interest in science. There was no significant difference between text and film groups in course achievement. There was significant difference between groups on the information included in the films only. Retention over three months favored the control group at the .01 level.

Studies such as Wittich's suggest that though films can be as effective as regular classroom instruction in providing for student achievement they can be over done. The negative feelings of teachers toward film usage, the feelings of constraint on time by students, and the higher interest in science of the nonfilm group suggest caution in using film as the primary means of instruction.

Twiest (1968) evaluated the effectiveness of the use of author produced filmstrips supplementary to dissection in high school and college biology classes. Two similar biology classes taught by the same instructor were used as experimental and control groups in five schools. The experimental groups previewed the appropriate filmstrip before a dissection lab. During the following lab periods, students were free to run the filmstrip. In the control section class was conducted in the conventional way without the use of filmstrips. All students were given an investigator made pretest of anatomy knowledge. After dissection students were administered a test of knowledge and recognition. Results showed no significant differences between the groups.

Woodman (1970) investigated the effectiveness of 15 PSSC films on physics achievement and understanding of science. 486 students in 9 high schools in Massachussetts were divided into 3 treatment groups - 1) no science films, 2) 15 PSSC films closely related to questions on PSSC achievement tests, and 3) 15 PSSC films unrelated to PSSC tests. Measurements of physics achievement were the PSSC tests. The Test of Understanding of Science (TOUS) was also used as a pre- and posttest. Significant differences ($p < .05$) were found in achievement to favor the no film group. No significant differences was found between groups 2 and 3. No significant differences were found on the TOUS. Boys in group 2 scored significantly higher ($p < .05$) on PSSC tests than girls. No differences were found in response to the PSSC films by IQ or prior achievement in science.

Woodman's results for physics students indicates that films are ineffective in producing significant achievement in science. However, one must be cautious in interpreting this result. As in Wittich's study it may simply be too much of too many films. A more judicious choice of films to show what cannot be shown by other methods rather than using film as the primary medium of instruction may be a useful approach to the use of films in science. Woodman's conclusion is also warranted. He urges that selection of films for classroom use in science should be on something other than for student achievement.

Peters (1972) conducted a study on the utilization of field trips and sound films. The treatment group recieved science content films in the classroom. The control group went on a series of field trips related to the same content as included in the films. Concept development was measured by means of a posttest. There was no statistically significant difference between the methods in student achievement. Peters concluded that films could effectively be used in the classroom to eliminate time consuming travel, could permit increased student exposure to various resource sites, and could eliminate direct contact with dangerous resource facilities.

Brown and Ladd (1974) compared an audiovisual program consisting of slides, filmstrips, and audiotapes with field trips on achievement of fifty students in an earth science course. The program was evaluated and revised weekly with the number of lectures increased to two by student demand. After one semester student test scores were compared. There were no significant differences between treatments.

Both Peters and Brown and Ladd have demonstrated the effectiveness of film as compared to field trips. This could mean considerable savings in time and expenses for courses in science. However, such comparisons are dependent upon the availability of films with content which meets the specific needs of the courses in question.

Trohanis (1975) studied Audible Multi-Imagery (AMI) programs (three screen slide presentations with audio) for the effect their lengths have on learning and retention. 253 high school psychology students in ten classes were divided into experimental and control groups. One class was used as a control group. One thirty minute AMI program on introductory high school psychology was developed. The program was arranged so that it could be broken down into three ten-minute segments. The experimental groups were divided so that they were shown program segments of 10, 20, and 30 minutes. A posttest was prepared and administered for each segment. Results indicated that the ten-minute segments were more effective than 30 minute segments. There were no significant differences between the ten and 20 minute segments. There was no significant difference in long term retention.

Allen (1975) investigated the effect of viewing a single concept 8 mm film on second, fourth, sixth, and eighth grade students' response to a set of questions related to the film. The 293 students who participated in the study were randomly assigned to three different groups at each grade level. One third saw the single concept twenty minute film on biological food chains. One third saw a similar film but without the food chain information. One third served as controls and viewed no film. Pre- and posttests were given. On the factual portion of the test the concept film group significantly ($p < .01$) outperformed the other two groups. The author concluded that film does teach factual content at all grade levels tested.

Tyson (1976) reported a study of cancer education and awareness program on 429 secondary school teachers and 7,633 secondary school students and their parents. The presentation was a one-hour lecture slide program. Two weeks following the presentation questionaires were administered. Results showed that teachers and students increased knowledge of cancer information, teachers showed more correct responses than students, and 92% of the teachers judged the presentation to be of value.

Chan (1977) described an audiotutorial slide program for zoology students. A self-paced system was devised for observing the content covered in twelve study units. The post testing evaluation revealed that students with lower grade point averages achieved scores comparable with students of higher grade point averages.

Feshbach, Jordan, Dillman and Choate (1978) compared the effectiveness of using slides and graphics and a numberic method of transmitting nutrient information on 88 subjects ages 4 to 10 years. Results indicated that subjects could understand the complex relationships at an earlier age using slides. Slide presentation was judged to be superior to numeric presentation.

These studies overwhelmingly demonstrate that film is an effective means of providing for student achievement in science at both the elementary and secondary levels. As with other media preparation and follow-up significantly increase effectiveness. The most effective use of film seems to be in combination with other instructional strategies rather than as the sole means of instruction for effecting student achievement.

RESEARCH ON THE EFFECT OF FILM ON STUDENT ATTITUDE

A number of studies on the use of film in science education have focused primarily on attitude change. The following seven studies are representative of such investigations.

Schweitzer (1963) investigated the effect of color and black and white films on attitude modification. Specifically, he questioned whether color enhances efficiency of instructional sound films, whether it contributes to retention, and whether students express a preference for color films. The following conclusions were reached. 1) Color in some cases did enhance the effectiveness of instructional sound films in modifying attitude, 2) color films maintained a slight but statistically insignificant advantage over black and white film in retention of attitude, and 3) there was a consistent preference for color films over black and white for both sexes.

Wickline (1964) investigated changes in attitudes of high school students concerning science and scientists after viewing a series of ten motivational films. An experimental group of 113 students was composed in two sections each of tenth grade biology, eleventh grade chemistry, and twelfth grade physics. A control group of 131 students was composed of two sections of tenth grade biology, one section each of eleventh grade chemistry and American history, and one section each of twelfth grade physics and sociology. Both groups were pretested with the Allen Attitude Scale and the Facts About Science Test. The experimental group was then shown one film per week until all ten films in the Horizons of Science Series had been shown. The two tests were administered as posttests. There was no significant difference in changes in attitude between the film and no film groups. None of the six variables of grade level, course content, mental age, total SCAT scores, sex, or elective science courses was found to be significantly related to changes in attitude. Differences in changes in understandings of science between the film and non film groups was significant ($p < .05$). The understandings of the film group increased slightly while the control group got worse. The films provided positive reinforcement for the experimental group resulting in a slight improvement in understandings as compared with a definite decrease in understanding for the nonfilm group.

Dunfee (1967) reported in a review of educational research literature that Allison had reported favorable attitude change of fourth, fifth and sixth grade students toward science, scientists, and science careers after viewing a series of science films. Allison (1966) investigated effects of treatment (film), grade level, mental age, science achievement, sex, and science training of parents in relationship to student attitudes. The Allen Attitude Scale was used as a pre- and posttest. Group 1 received no films, Group 2 viewed films only, Group 3 received film and discussion, and also received questions prior to the films, Group 4 viewed the films and discussed them with the investigator, Group 5 viewed the films and discussed them with their regular teacher, Group 6 did not view the films. Attitudes toward science, scientists, and careers changed favorably by all treatments. Changes in attitude were not related to grade level, mental age, achievement test scores, or science training of parents.

Trinklein (1967) reported a study of using full film and excerpts on attitude formation and achievement of 382 students in Chem Study. A combination of whole film and excerpts produced greater gains in knowledge and attitudes than either film or excerpts alone.

Deture and Koran (1975) compared the effectiveness of live peer presentations versus filmed peer presentations on 22 fourth grade students from a deprived neighborhood. Two groups of students were selected to perform a science activity. The treatment group first watched a filmed explanation of the activity. The control group did not watch films. The treatment group generated significantly more positive behaviors and less negative behaviors in the activities.

Simons (1980) studied the effect of structure of film narrations on achievement and attitudes of 70 tenth grade biology students. The study extends the research on the positive effect of structured lecture presentation on achievement and attitudes to film. Intact classes randomly selected to participate in the study were divided into two groups each viewing two films, one with high structured narration, one with low structured narration. Pretest of knowledge of film content was given. Three posttests, free recall, affective test, and multiple choice test were given following the film. High structure film groups showed statistically significant ($p < .05$) differences over low structure film groups on all measures. The author concludes that film producers need to better attend to film structure to enhance knowledge acquistion and promote affective responses to film content.

Simmons echoes the same challenges to film producers made by Barnard (1956), that is film producers need to attend more closely to the structure and composition of their creations in order to maximize their effect. It seems clear, however from the numerous studies cited thus far that film can not only enhance effective learning, but can also effect significant changes in student attitudes toward science, toward scientists, and toward science careers.

RESEARCH ON THE EFFECTS OF MANIPULATION OF VARIABLES USING FILM

A number of studies thus far reported in this paper have involved manipulation of parts of the film presentation to determine the best or most effective use of film with students. Hall, Johnson, Vandermeer (1964) for example studied effects of differing presentation of filmstrips; Brown and Ladd investigated combinations of film presentation as did Trohanis (1975); Schweitzer studied the effect of color; Allison (1966) studied combinations of film and discussion; Trinklein (1967) looked at using whole films versus excerpts; and Simmons compared the effects of structure of films. A number of other studies, some of which are reported in this section, have investigated other variables in relationship to film usage in the classroom.

Murphy (1961) studied the effectiveness of filmed introductions to a general science film on achievement and retention of seventh grade students. 271 students were randomly assigned to 5 treatment and one no treatment groups. Three types of filmed introductions were tested: 1) presentation of technical vocabulary, 2) general description of content, and 3) a set of questions directed toward the content presented in the film. None of the treatments produced statistically significant differences over use of the film alone or to one another. All treatments were superior to no treatment. Lower IQ students' means increased as more information was added to the beginning of the film.

This study though not specifically stated is related to a number of other studies on the use of advance organizers on student achievement using film. David Ausubel has suggested that presentation of advance organizers in directed or nondirected instruction significantly enhances student performance and achievement. Murphy's data seems to suggest that such advance organizers do not have an effect on achievement.

Thelan (1970) studied the effect of advance organizers and guide questions used with seven earth science films in effecting achievement and attitude changes in ninth grade students. 340 students were randomly assigned to four treatment groups. Only 137 who had completed all parts of the experiment were included in the analysis. Group 1 had advance organizers five minutes before the films plus guide questions and discussion after the films. Group 2 had guide questions and discussion; Group 3 had advance organizers and discussion. Group 4 had discussion only. No significant differences were found in achievement or retention. Students not using advance organizers demonstrated a significant difference in attitude change toward film as an instructional tool. Change in all groups for attitude was negative.

Teather and Marchant (1974) investigated the effects of cueing, questioning, and providing knowledge of results along with films on students in educational psychology. These devices were incorporated into the films to encourage learner participation diring brief intervals in the film showing. Results showed that the effect of cueing, that is, the presentation of items of information via a learning booklet prior to showing the film did not show statistically significant results. Following the student's attempt to answer a question by the correct answer was significantly more effective than questioning without the correct answer.

Lawton and Wenska (1979) studied 237 rural kindergarten, third and fifth graders to determine their learning and retention resulting from three types of advance organizers. Students were administered the Peabody Picture Vocabulary Test. Those scoring in the lower 25% were randomly assigned to one of the three treatment groups; 1) high order concepts, 2) high order rules for classification, 3) combined content and process. Control group received no treatment. Advance organizers were slides and picture cards designed to enhance content and organization development. Group 3 was most effective for all three groups ($p < .05$) for achievement and retention.

Bowyer (1979) investigated the influence of visual and verbal organizers on cognitive learning from films. Students in seventh grade (193 subjects) were divided into high, medium, and low levels based on achievement on a standardized science test. Experimental groups were given visual introductory materials for the films. One group was told to write about the materials, the other was given no instructions. A control group received a written summary. Students viewed several science films and were tested on their content. A retention test was given several weeks later. No significant differences were found between groups.

The question of use of advance organizers in combination with film is thus in question. In some instances advance organizers appear to enhance achievement in using film, in others there are no significant differences when they are used and when they are not.

Moakley (1968) tested the effects of periodic variations in an instructional film's normal loudness level for relevant and irrelevant film sequences. Rigorous pilot studies, random grouping of seventh grade students for treatment, and ratings of relevant and irrelevant film portions by an unspecified number of judges preceded the experiment. An analysis of variance for the four experimental groups suggested that higher mean performance was a result of decreases in loudness rather than increases, regardless of relevancy of material Another analysis suggested that decreases in loudness for irrelevant material resulted in higher performance than decreases for relevant material. For the three control groups whose film sequences were constantly relevant more learning resulted from loudness levels both above and below normal than from a normal level. High performance levels were positively related to high intelligence levels.

Mori and Tadang (1973) investigated the effects of abnormal motion picture films have on influencing a student's perception of space and time. High speed films were projected for 3 min. 7 sec. while slow motion films were projected for 6 min. 11 sec. The high speed films were shown to 42 twelve year olds and 59 six year olds. Slow speed films were shown to 45 twelve year olds and 35 six year olds. Before and immediately following viewing each subject was tested on judgement of motion. Results showed a significant difference ($p < .01$) for both age groups who viewed the high speed film.

These studies suggest that abnormal adjustments in the use of films in the classroom have significantly different effects on student achievement and perceptions. This is particularly important where particular emphasis is desired or in the case of film speed where perception of motion is important to concept development.

Blomberg (1974) compared the effectiveness of the laboratory approach, standard reading/lecture, and films on overt behaviors of sixth grade students in 2 schools. Four groups selected at random studied the ESS units over three 6 week periods. The film group used ESS film loops and videotapes. The Overt Behaviors Test which identifies student actions such as tell, write, show, demonstrate, and construct was given as a pre- and posttest. Results showed no significant difference in the three teaching methods. There were no significant differences due to sex.

Blomberg's study is interesting in that it shows that films can be just as effective as other teaching methods in affecting student behaviors. However, it is difficult tc see how such a short treatment would be expected to change significantly student behaviors after being in school for 5 to 6 years.

A few additional studies have investigated some interesting aspects of the use of film in science classrooms.

Kazem (1960) selected two types of film, the informational/expository and the historical/dramatic to be seen by tenth grade biology students to discover their effect on understanding scientific method. Students were matched by prior achievement, intelligence, sex, age, school and grade. Posttests showed a significant increase in understanding of the scientific method in all treatments. The informational/expository film made a significantly greater contribution to understanding than the historical/dramatic. The films viewed together made a greater contribution in student gains than either viewed alone. There were no significant differences by ability level.

Barker (1969) created four single topic film loops and corresponding teacher guides designed to elicit hypothesis formation on the part of high school students. 100 chemistry students were shown a sequence of the films. A first hypothesis was constructed immediately following the film display. Students were then shown experimental evidence and allowed to revise their hypotheses. There were no significant differences between the original andrevised hypotheses. Approximately 60% of the students could construct relevant or modified hypotheses. The relevancy of the hypotheses was significantly greater for the revised hypotheses. There was a significant improvement in the ability of students to construct hypotheses from the first to the fourth film.

Castelli (1970) investigated the effect of 20 BSCS single topic film loops on critical thinking abilities of high school sophomores. Using a four group design and analysis of variance the Watson Glaser Critical Thinking Appraisal and the Processes of Science Test were administered. Results indicated that critical thinking ability can be improved using an inquiry film, but process skills appear non effected.

These few studies indicate that films may have several unanticipated effects other than achievement and attitude change. Films appear to be able to effect such things as understanding of scientific method, constructing hypotheses, and critical thinking abilities.

SUMMARY

Though many of the films, filmstrips, slides and other film media may be strictly expository in nature and have low quality subject matter or production (Barnard 1956; Razum 1972) there still remain a substantial number which can be effectively used in the science classroom to enhance student achievement, attitude development, and other student behaviors. This research review supports the conclusions of Wittich and Schuller (1979). Hubbell (1957), Wittich (1967), Peters (1972), Brown and Ladd (1974), Allen (1975), and Chan (1977) have shown that film and still projection can be an effective instructional medium for communicating factual information and certain skills. Film is not always effective, however. Tweist (1968) and Woodman (1970) found film to be ineffective in their studies. Wickline (1964), Deture and Koran (1975) and Simmons (1980) have also demonstrated that films are effective in changing attitudes of students in science.

Wittich and Schuller (1979) have also concluded that combinations of instruction are most effective, that when media is used with proper student preparation and follow-up it is most effective. This position is clearly supported by Hall et. al. (1964), Murphy (1967), Tyson (1976), Deture and Koran (1975), and Feshbach et.al. (1978).

The evidence on the use of advance organizers with film is less clear. Studies by Blomberg (1974), Thelan (1970), Teather and Marchant (1974), Lawton and Wenska (1979) and Bowyer (1979) are conflicting. Other variables manipulated in use of film may also have differential effects. Moakley's (1968) studies on the effect of loudness for example are not clear. Changes in sound level and film speed (Mori and Tadang 1973) seem to have differntial effects of students achievement and perceptions. It also seems that film can effect changes in hypothesis formation (Barker 1969) and critical thinking abilities (Castelli 1970).

CONCLUSION

There is no question that film and still projection are effective means of instruction in science clearly capable of significant improvements in achievement. It also seems clear that film is effective in changing student attitudes toward science, scientists, and science careers. Factual knowledge expecially of content not readily accessible to teachers or students can be effectively communicated to students through the use of film.

What is equally clear is that without specific planning as to the use of the film including thorough student preparation and follow-up, effectiveness is significantly diminished. This is no different than what could be said of the use of any instructional aid. Film seems most effective when used in combination with other instructional strategies. Students need preparation before viewing film so that they know what they are to do, what they are to observe, how it is relevant to their current studies, etc. Use of advance organizers in preparation for viewing seem to be effective in some cases but not in others. It may be that the particular kind of preparation needed varies with content and students.

In addition to effecting changes in achievement and attitudes film may also have some unexpected side effects. It appears that film can effect changes in understanding science process, in improving hypothesis formation, and in improving critical thinking skills.

As mentioned earlier film is especially useful to the science teacher in being capable of bringing into the classroom through photography, magnification, animation, and time-lapse resources, experiments, and information not available in any other form. The research also shows that unless the teacher is familiar with the content and is clear about the intent of the film it is perhaps better not to gamble with class time. This suggests that teachers should plan and preview before using film media in the science classroom.

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Chapter 3

AUDIO

EDUCATIONAL COMMUNICATIONS AND TECHNOLOGY AS APPLIED TO SCIENCE EDUCATION IN INTERMEDICATE/MIDDLE SCHOOL

AUDIO

INTRODUCTION

A third type of media used in education is audio. This category includes recordings, audiotapes, audio-tutorial, radio, language laboratories, and dial access systems. Audio learning as used in this chapter refers to "learning that occurs through exposure to electronically recorded or broadcast explanations, directions, and the like" (Wittich and Schuller 1979, p. 142). Because of the variety of combinations of the use of audio with other instructional media, it is difficult to isolate the actual contributions of the audio portion to learning. In science, the most commonly used forms of audio instruction are audiotapes and audio-tutorial systems. There is somewhat lesser reliance on radio in science and little use of the other modes of audio instruction.

Taped instruction has several advantages as noted by Wittich and Schuller (1979). Taped material can be played back an indefinite number of times without substantial loss of quality of message. This is a particular advantage with the recent emphasis on individualized instruction. Audio learning can be effective in developing skills. Audio tapes have been used to instruct both adults and students in the operation of equipment and/or the performance of required tasks. Again the capacity of the tapes to be played back over and over, slowed down, or speeded up enable learners to progress at their own individual rate. Audio instruction also frees teachers from needless repetition enabling them to better serve the needs of individual students. As with other media, however, the effectiveness of audio instruction is only as good as the instructional plan, that is, with proper preparation and follow-up activities or discussion.

The remainder of this chapter is divided into three sections, radio, audio tape studies, and audio-tutorial studies. These are the primary uses of audio instruction in science.

RADIO STUDIES IN SCIENCE EDUCATION

Radio is a primary means of instruction in rural areas and for correspondence schools. For example, students living in the outback of Australia rely heavily on radio for their eduction. Radio also serves as a useful means of bringing information into the classroom (Wittich and Schuller 1979).

> Barnard (1956) reviewed the research on instructional methods and materials utilization in science. He concluded that if teachers were not sure of the quality of the audio instruction (that is for commercially produced or locally produced materials) or the content they should not use it. Though it is difficult to preview radio broadcasts Barnard found that the studies he surveyed showed that radio instruction in science could be effective in effecting achievement in science. When carefully selected with a definite purpose in mind, with student preparation and follow-up radio broadcasts in science have educational value.
>
> Uslan (1964) assessed the attainability of geographic and related physical science concepts by fifth grade students using short wave radio broadcasts. Two groups of students consisting of 34 students each were involved in the study. One group used radio, the other followed a conventional instructional program. Results showed that the radio group performed better in written responses ($p < .01$), in listening ($p < .05$) and in subject matter content ($p < .01$).
>
> Miles (1940) examined the effects which radio instruction had on increasing knowledge, developing favorable attitudes, and extending interest in conservation of wildlife and natural resources. Six-hundred-fifty-one students took part in the one semester study. Ten classes of fifth and sixth graders listened to radio broadcasts. Ten control classes of fifth and sixth graders did not receive the broadcasts. A pre- and posttest consisting of information, attitude and interest items was administered. Results showed significant increases in information and significant shifts in attitudes ($p < .05$) for the treatment group. No significant differences were found in interests, but the fifth graders in the nonradio classes exhibited significantly greater increases than the radio groups.

Though only a few studies of radio in science were found they support the contentions of Wittich and Schuller that radio can be effective means of science instruction. It appears that the major drawback of using radio broadcasts in the classroom is that it is more difficult to know ahead of time what the commercially broadcast programs will be. This could be alleviated by providing an annotated program listing much as is done for the Nova TV series.

AUDIO TAPE STUDIES IN SCIENCE EDUCATION

Audio tape is probably the most widely used of the audio media in the science classroom with the possible exception of audio-tutorial which will be dealt with in the next section. Audio tapes are used to instruct in the use of laboratory instruments (Gore and Rayner 1972; Wittich and Schuller 1979), for individualized instruction, to convey information in science, and perhaps most significantly are a primary means of instructing the blind (Eichenberger 1974). The following seven studies are concerned with audio effect on achievement.

> Hoffman (1969) compared direct and indirect audio taped lectures for effectiveness with ninety college freshmen biology students. The students were randomly divided into two groups. The first was taught directly by audio taped lectures, laboratory exercises, and guide sheets. The second group participated in question and answer activities in addition. Pre- and posttests were administered at the beginning and end of the eight week course. A retention test was given ten weeks later. No significant differences were found at the end of the course or on the retention test. Both groups did favor the audio tape approach as a teaching method. The indirect group was also described as demonstrating improved problem solving skills.

It is not clear from the report of this study what the actual test was. In one instance it is referred to as an "aptitude" test making the interpretation of results difficult. However, the audio approach was favored by both groups and again the combination of instructional methods seems to be most effective.

> Holliday (1970) compared the use of audio tapes and printed material on student achievement and retention of science content in tenth grade biology. Three-hundred-fifty students were randomly assigned to nine subgroups identifiable by the unique combination of programmed text format, group-paced delivery techniques utilized for each in the subsequent learning and testing sessions. No significant differences were found in either verbal presentation or in using a combination of audio and printed media simultaneously, nor in using the same media in the learning and testing sessions. The author interpreted the data to mean that one of the two media in the simultaneous presentations was not used to interpret the learning material. He raises questions concerning using audio and printed materials for instruction.

Holliday seems to suggest that the combination of media are somehow interfering with one another. This is quite contrary to other research data showing that combinations are, in fact, more effective.

Presnell (1971) developed and evaluated an audio taped program of instruction in learning concepts of ecology and conservation, as well as, interpretative skills which serve as prefield trip instruction. One-hundred-thirty-eight students in the upper elementary grades were exposed to audio lessons, field trips and five written tests. A control group of 98 fifth and sixth graders were administered the tests only. A series of ten 27 minute sequential audio taped lessons were produced. Students listened to these lessons on an individualized basis via cassette tape recorder. Results indicated that while many concept, fact, and skills learning gains occurred, few were significant. It was also shown that few significant differences in learning gains occurred between field experienced and non experienced students. The author concluded that based on the results the program was best suited for sixth grade students.

Presnell seems to show differential effects of instruction on students of different age levels. Treatment of the control groups is not altogether clear making interpretation difficult. If we assume adequate controls and comparable treatment, audio instruction does not seem to be any more effective than other means of instruction.

Luttrell (1971) studied 52 seventh grade students who were enrolled in an individualized science program (ISCS) to identify the degree to which students with reading difficulties could perform if provided with supplementary audio instruction. Students were divided into two groups. The control group and the treatment goups both studied ISCS Level I material. The treatment group received supplementary audio tape recordings that repeated the content orally. Results from an ISCS achievement test and the Comprehensive Test of Basic Skills indicated no significant difference in the performances of either group. The treatment group had greater gain scores in achievement. There were no significant differences in gain score in reading or math.

This appears to be a follow up study of Holliday's 1970 study. Again he found no significant differences indicating that audio tape is as effective as other more conventional means of instruction.

Atkinson (1972) studied the comparative effectiveness of audio tape and printed material on achievement and retention and on time to complete a required sequence of activities. Seventy-two eighth grade science students who were below or above average in reading ability were randomly divided into two groups. The experimental group received instruction by audio tape. The control group received instruction through printed material. Posttests were given to all subjects after each chapter and a cumulative test was given three weeks after all five chapters had been completed. A retention test was given three weeks after the end of the experiment. Results of the study showed that there were significant differences in favor of the audio tape group. The above average reading ability students got higher achievement and retention scores with printed materials.

Atkinson has shown that as with other media means of instruction is differentially effective on students of differing abilities. The audio tape mode seems in this study to be very effective with low readers.

> Kroll (1974) tested the relative effectiveness of written and audio tape instruction on 120 fifth and sixth graders. Students were randomly assigned to four groups; high ability students with audio; high ability students with written materials; low ability students with audio; low ability students with written materials. A published programmed text in elementary science adapted to a prose-plus-adjunct question format was used. Findings suggested that both high ability groups learned the material equally well regardless of means of instruction. Both low ability groups learned less from the treatments. Reading and audio were equally as effective.

Kroll, Holliday, Luttrell and Presnell and others all have found that audio tape is as effective as other means of instruction. This would suggest that selection of the media for science instruction should be based on something other than acheivement gains. For example, if audio tape instruction is utilized the teacher is free to interact with students who may need additional help.

Audio Feedback

A couple of studies have dealt with the effectiveness of audio feedback. Tauber (1971) for instance studied the effect of four feedback mechanisms on student performance in high school science. Students (224) in grades 10, 11, and 12 were randomly assigned to 4 treatments; 1) no comment - lab reports returned with just a grade, 2) limited comment - grade plus short word or phrase, 3) free writing - grade plus long written response, and 4) free tape - grade plus 3 to 8 minutes of teacher comment on tape. No significant differences were found on student performance scores on the lab exercises overall. Subanalysis showed significant differences in favor of the free tape ($p < .05$) for chemistry students. Physics classes showed significant differences ($p < .05$) in favor of no comment. Though apparently showing differential effects due to subject matter, ability level may well enter into this study as an intervening variable since it is common for only the highest ability students to go on from chemistry to physics. Further maturation must also be considered. Though such tape feedback mechanisms might be easier for the teacher than writing long responses, their effects are not clear.

Compressed Speech

A number of experiments have dealt with compressed speech, that is, audio materials played back at a rate faster than normal voice speeds. Compressed speech is possible without changing the pitch or inflection of the original voice.

Wittich and Schuller (1979) in reviewing the research on compressed speech state the following conclusions:

> 1. Between 90 and 95 percent of the students using compressed speech derive satisfaction from the opportunity to change their listening speeds.
> 2. As materials become more understandable to listeners they usually increase their listening speed. Listening speeds can be increased as much as 50% with no loss of comprehension.
> 3. Most students have the potential to listen to and comprehend information at rates substantially faster than normal speaking speech.

The following three studies look at the use of compressed speech in science instruction.

> Sarenpa (1971) made a comparative study of two different types of audio tape instructions. One test group of 28 college students heard the tapes compressed 60%. The control group of 29 students heard the tapes at normal speed. While the compressed speech group had a 12.3% savings in time there were no significant differences in achievement.
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> Rippey (1975) reviewed the research on compressed speech and found that there were no significant differences in achievement but substantial savings in time. As the rate of presentation increases so does the rate of learning. The speech compressor is more effective if students can control the rate of speed, this being a crucial factor in acceptance of compressed speech.
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> Perrin (1976) investigated the effects of two presentation variables screen size and rate of presentation, and sex on cognitive learning of middle school students. Four identical slide sets were prepared. Two normal speed tape recordings were made to accompany the slides. Two 40% compressed speech tapes were also prepared. A test instrument was prepared to assess the audio, visual, and audiovisual content of the presentation. The test population was 118 above average middle school students randomly assigned to the four treatment groups. The posttest was admin-

> istered immediately following the presentation and again 3 days later. Learning from the large screen presentation was not significant on the posttest, but was ($p < .05$) on the retention test. Compressed sound was significantly less effective ($p < .05$) than normal sound on both immediate and retention tests.

These studies show differential results but also deal with different age groups. It may be that compressed speech is more useful with some groups than with others. It is surprising to find that in Sarenpa's study students were so quick to adapt to the use of compressed speech. Perrin's study may have shown different results if students had time to become accustomed to the use of compressed speech and, as Rippey indicates, could have control over the rate of speed.

Other Audio Tape Studies

A number of other studies have been conducted using audio tapes in science. Some of these are reviewed below.

> Gates (1970) investigated the effectiveness of audio tapes when used as a supplement to reading the ISCS Level I materials. Students classified as poor readers were divided into two groups, and audio group ($n = 50$) and a control group ($n = 50$). The audio group listened to audio cassette tapes of a narrator reading the ISCS materials. The control group was instructed by the same teacher but did not use the audio tapes. Results obtained after one year of treatment indicated that the group using audio tapes had a significant superiority ($p < .05$) over the controls in preference for science achievement, and reading comprehension. No significant difference was found for understanding of science, overall reading grade level, or rating of teacher performance.

This study seems to be particularly well done over a long enough time frame to be believable. The results confirm studies already summarized that audio tape may in fact be a significant learning device for low ability or low reading students.

> Barry and Carter (1972) researched the use of a variety of instructional media in a general chemistry course. These included 16 mm sound motion picture, slide/tape programs for individual student use designed to teach analytical skills, slide/tape programs covering lecture topics. Results showed that achievement of students using the slide/tape programs was superior to those who did not. Achievement increased with time invested in using the slide/tape programs. A slightly higher proportion of low ability students chose to use the slide/tape materials and spend

more time on them than higher ability students.

> Simons (1972) compared two instructional techniques which involved 64 students in two experimental groups and 65 students as controls. Two instructional treatments (scripts and tapes) and two units of biology were utilized. One experimental group was given audio tapes, the other written materials for the first unit. In the second unit the instructional media was switched. Pre- and posttests were given for each unit. Reading ability, student attitude toward the technique used and subject content were studied. The relationship of scholastic ability to achievement to achievement was also studied. A significant difference favoring script instruction was found for achievement in the developmental biology unit. No significant difference was found between tape and script groups for the unit on genetics. Attitudes toward the treatments differed favoring the multi-method approach.

Simons study seems to indicate that not only is achievement related to ability, with higher ability students learning more than lower ability students, but that use of audio techniques may also be subject matter dependent. This would account for the different results found with the two different biology units and for the differnces in achievement found by Tauber (1971).

> Hosley (1974) compared field out-of-door approach and an Audible Multi-Imagery (AMI) presentation on concepts of balance of nature in environmental education units with 100 fifth grade students. Students were selected at random and divided into 4 groups of 25 students each. Group 1 received no instruction. Group 2 received the AMI presentation. Group 3 went on the field excursions and Group 4 did both. An achievement test administered after treatments showed that students in the AMI group scored as high as student participating in the field trips. Students viewing the AMI presentation scored significantly higher ($p < .05$) than students receiving no instruction. Students receiving both AMI and field excursion scored the highest.

Audio tape instruction can be as effective as other means of instruction, may have differential effects by student ability level and/or reading level, and may have differential effects due to subject matter. Its most significant appeal seems to be in freeing the teacher from unnecessary repetition and facilitating individualized instruction in which students can control the rate of presentation.

AUDIO-TUTORIAL STUDIES IN SCIENCE EDUCATION

The second most frequently used audio media in science classroom appears to be audio-tutorial. The recognized initiator of the audio-tutorial method of instruction is Samual Postlethwait who in 1961 first combined the relatively inexpensive technology of audio tapes with an individualized, self-paced approach to teaching introductory college biology courses (Postlethwait 1963). Since that time the audio-tutorial method has been adapted to many other subject areas at the college level where most of the research on its effectiveness has been conducted and reported. Kahle (1978) summarized the research as basically comparing two groups, audio-tutorial and non audio-tutorial. Most studies followed the pattern already established for assessing the effectiveness of TV instruction. Most suffer from the need for randomization, equivalency of groups, and the appropriateness of the evaluation instruments.

Novak, Ring, and Tamir (1971) summarized the early research studies on effectiveness of audio-tutorial as, at best, as good as traditional instruction. They also indicated that there were suggestions of differential increases in achievement in favor of low ability groups. Subsequently, Nordland et. al. (1975) showed that students below the 40th percentile on ability measures achieved higher with audio-tutorial instruction than they were predicted to achieve.

> Kahle et.al. (1976) tested the effects of audio-tutorial instruction on a population of low ability students over a five year period. A-T modules with low reading levels, high interest levels, and appropriate cultural and ethnic references were developed. Standardized pre-/posttests were used to establish equivalency of groups. Records were kept of time spent on task. The A-T module was found to be as effective as traditional mode of teaching for disadvantaged learners. Self pacing significantly contributed to learner achievement. A-T was found to be more efficient mode of instruction.

A-T Instuction at the College Level

Fisher (1976) surveyed the existing research on the use of A-T in college science teaching. Despite the scarcity of research in refereed journals, he was able to locate a number of apparently valid studies. He found that:

> A-T college science teaching is nearly always equal to, and often superior to lecture methods in content learning. Of 25 comparative studies, 17 favored A-T, 7 found no significant difference, and only 1 favored lecture.

Students believe they learn more by A-T methods

Student attitudes toward A-T teaching tend to be strongly positive. The aspect of A-T teaching most often cited as being of value to students is the autonomy and self-sufficiency in learning made possible.

A-T is economically advantageous. Though initial costs are high it is paid back in 2-3 years.

The following ten studies are typical of the research on the use of A-T at the college level.

Thorsland (1970) studied the use of A-T in physics. Four-hundred-twenty students in the elementary physics course took part in the study. Half received A-T instruction, half received regular instruction. A-T groups achieved slightly below the non A-T groups, but differences were not significant.

Husband (1970) studied an A-T freshman botany course which had been operating for 4 years to determine the effect of grade in an oral quiz session on student learning. Subjects were divided into three groups. Group 1 was given an oral grade by the instructor. Group 2 no oral grade was given. In both groups 1 and 2 the instuctor selected respondents. In group 3 no oral grade was given and respondents volunteered. There were no significant differences reported in achievement of the groups.

Arnwine (1970) studied A-T in a general biology course. Cassette tapes were substituted for class lecture. Other media supplemented the tapes. The instructor met with small groups for two 1-hour sessions each week. Grades for the 18 participants were significantly higher than predictions based on past classes.

Quick (1971) investigated the effectiveness of a self-developed A-T system compared to lecture-laboratory approach in biology. Over the semester five types of tests were administered. Results showed higher achievement on the part of the A-T students.

Hoffman and Druger (1971) compared two different A-T methods, direct, in which students passively receive lessons of a descriptive or expository nature and an indirect method, in which students use a guided question-answer technique. They found the two strategies equally effective for teaching facts, concepts, principles, and equal in retention. Neither strategy improved critical thinking abilities. Problem solving abilities, yowever, were significantly enhanced by the indirect method.

Hill (1973) found that supplementing A-T materials in an otherwise traditional lecture course in chemistry significantly enhanced student creativity and laboratory skills.

Both Hoffman and Druger and Hill indicate that A-T may have significant effects on outcomes other than factual recall. One of the primary objectives of most science programs today is to develop problem solving abilities, critical thinking and laboratory skills. A-T may be a significant contibutor in these areas as well.

> Rowsey and Mason (1975) analyzed two methods of instruction in an animal biology course to determine outcomes in student achievement and retention. One group (n = 134) received A-T instruction. The other (n = 190) received instruction in the conventional lecture-laboratory format. Pretest, posttest and retention test data were collected using the Achievement in Biology Test. Results indicated that the group taught by the A-T method scored significantly higher ($p < .01$) on both the posttest and the retention test given 11 weeks after course instruction.
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> Collins (1975) designed three A-T units for biology and tested their effectiveness on 650 students. The A-T method was effective in that 70% of the students achieved the stated objectives.
>
> Fisher et.al. (1976) conducted an evaluation of A-T in a genetics course with 623 students. Two control groups and one experimental group were used. The experimental group had significantly lower scores on the pretest and significantly higher scores on the posttest.
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> Mathis and Shrum (1977) examined the relationships of kinetic structure, time spent on A-T, verbal ability, and achievement in an introductory biology course. Kinetic structure is a measure of the relative sequence of material presented and the relative relatedness of adjacent thoughts in verbal communication. No relationships were found between time spent on A-T, kinetic structure, and verbal ability. The authors concluded that high kinetic structure communications promote learning and that achievement is related to time spent on A-T.

These ten studies though mostly not included in Fisher's survey nevertheless support his basic conclusions. Most studies show no significant differenced in achievement using A-T. Few show A-T to be inferior to lecture-laboratory approaches at the college level.

A-T Instruction at the Elementary and Secondary Level

College studies of the effectiveness of A-T instruction are done more often and with larger sample sizes than studies at other levels. Colleges provide large classes especially at the introductory course level where most A-T instruction is used. In addition, access to students by researchers is not nearly as difficult at the college level as at the elementary or secondary school level. Thus the large quantity of research at the college level. One can assume, however, from the sample tested that such studies deal with higher ability students. Other research already cited shows clearly that there are differential effects by ability level. Though these college studies may give some indications of the usefulness of A-T instruction at lower levels, they may not be applicable to middle school. The following six studies refer specifically to lower school levels.

> Nussbaum (1971) tested A-T instruction with second grade students. The experiment was conducted with a sample of two groups of 26 students each. One group received A-T instruction followed by an interview test. The other group was interviewed without any formal instruction. In the analysis of the interviews five different notions of an earth concept were identified. The notions appeared in similar frequencies in both groups.

It would appear on the surface of Nassbaum's study that the A-T method was ineffective, however, it must be noted that there was apparently no time given to prepare students or acquaint them with the use of A-T instruction. This may contribute more to its apparent ineffectiveness that the content of the lessons.

> Netburn (1972) studied fourth grade students presenting selected science activities. The control group was the teacher using conventional instructional methods. The experimental group received A-T instruction. The A-T approach was as effective as the teacher instruction in achievement of students.

> Morrell et.al. (1974) conducted two studies using two different feedback techniques with 53 self-paced fourth graders and 85 group-paced fifth graders. A four track tape recorder with programmed units was used. Each teacher had both control and experimental students to reduce effect of teacher variable. Results were measured by overt responding in multiple choice format as well as weekly tests, criterion posttests, and anxiety and defensiveness scales. Results indicated that taped audio programmed instruction is equally as effective as teacher instruction.

> Nordland et.al. (1974) investigated the effectiveness of A-T in high school biology. Students were randomly assigned to one of two groups. The experimental group (n = 59) received A-T instruction. The control group (n = 59) was instructed in a group-oriented classroom situation. Four units of biology were covered in the three week experiment. Results showed that of biology were covered in the three week experiment. Results showed that A-T students scored significantly higher in the post achievement test ($p < .05$).

> Hauser (1975) sought to determine whether any cognitive style elements are related to A-T or print self-instructional packaged teaching strategies. Ninety-six high school biology students were assigned to either of the two groups. Results showed that the qualitative visual

> element composed the unique cognitive style of high achievers of A-T instructional stategy. Students who derived least cognitive knowledge from the A-T method preferred maximum meaning from reading or math symbols.

The cognitive preference testing is new to science education and is still in heated controversy as to what is really being tested. However, Hauser's study does suggest that differences in learning style and/or rate result in differential effects of the audio media.

Finally, Tamir and Amir have reported on the effectiveness of A-T in Israel schools.

> Tamir and Amir (1975) tested the A-T method of science instruction with 598 students; 473 experimental the rest controls. The population consisted of first and second graders. Experimental students received their science instruction via A-T, the control with their regular teacher. After one year of instruction the A-T group demonstrated significantly higher gains in science.

SUMMARY

This chapter has reviewed the research literature on audio media, specifically radio, audio tape, and audio-tutorial as they apply to science education. Though radio is not much used in science instruction at the intermediate or middle school level Wittich and Schuller (1979), Barnard (1956), Uslan (1974) and Miles (1940) have shown that radio can be an effective means of science instruction. Most studies show radio to be as effective as other means of instruction. Utilization could be improved for commercially broadcast programs if advance annotated announcements were made such as those prepared for the Nova TV programs.

Audio tapes are the most widely used of the audio media in science classes. They are effective for both information dissemination and skill development including laboratory skills (Gore and Rayner 1972; Wittich and Schuller 1979). In terms of achievement in science audio tapes are sometimes more effective than other methods of instruction (Presnell 1971; Atkinson 1972) but most frequently are shown to be as effective, that is, no significant differences (Hoffman 1969;

Holliday 1970; Holliday 1971; Luttrell 1971). Other studies (Presnell 1971; Atkinson 1972; Simons 1972; Kroll 1974) indicate that audio tapes have differential effects on students with low ability students gaining more from audio tapes that they can control. Compressed speech studies (Sarenpa 1971; Rippey 1975; Perrin 1976) show that students can learn more efficiently using compressed speech, that listening speeds can be increased as much as 50% without loss of comprehension (Wittich and Schuller 1979), and that such speech compressors are effective if students control the speed (Rippey 1975).

Audio-tutorial methods have been used extensively at the college level especially with large introductory classes with lesser use in elementary and secondary schools. Fisher (1976) has best summarized the results of research on A-T instruction at the college level. A-T instruction is nearly always equal to or better than lecture laboratory instruction. Students believe they learn more from A-T instruction. Student attitudes toward A-T instruction tend to be strongly positive, and that A-T instruction is cost effective with a payback time of 2 to 3 years. These conclustions are supported by Thorsland (1970), Husband (1970), Arnwine (1970), Quick (1971), Hoffman and Druger (1971), Rowsey and Mason (1975), and Fisher et.al. (1976).

The effectiveness of A-T instruction in elementary and secondary schools is less clear due to fewer clearly valid studies having been done and reported. However, the findings of effectiveness of A-T for college level science courses seem to be supported by Nussbaum (1971), Netburn (1971), Morrell et.al. (1974), Nordland et.al. (1974), and Tamir and Amir (1975).

CONCLUSION

Audio instruction including radio, audio tape, and audio-tutorial instruction though not shown to be more effective than other instructional strategies has nevertheless been shown to be consistently as effective as other strategies for effecting student achievement. Though it appears that as with other media of instruction the higher ability students learn more that lower ability students, audio is particularly effective with low ability or low reading level students especially when they can control the playback and speed of the recordings. No studies were found which investigated the effects of audio on attitudes toward science, however, several studies have shown that students of various age levels show favorable attitudes toward audio instruction.

With the evidence that audio instruction is as effective as other strategies selection of audio as a means of instruction should then be based on other criteria. Among these are its ability to address individual needs in that students can have access to the audio media when they need and as often as they need. In addition, teacher time is freed avoiding needless repetition and enabling the teacher to better address other student needs.

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Chapter 4

PROGRAMMED LEARNING

EDUCATIONAL COMMUNICATIONS AND TECHNOLOGY AS APPLIED TO SCIENCE EDUCATION IN INTERMEDIATE/MIDDLE SCHOOL

PROGRAMMED LEARNING

INTRODUCTION

This chapter will review the more recent research on programmed learning. Programmed learning includes programmed texts, teaching machines, learning laboratories, audio-tutorial, computer programs, computer managed instruction (CMI), computer assisted instruction (CAI), simulation and games, and dial access systems. Significant amounts of research have been conducted in this area during the last fifty years particularly with emerging educational concerns for individualized instruction. The following overview of research in this area will be divided into four broad sections, audio-tutorial, individualized instruction, programmed instruction, and computer assisted instruction.

AUDIO-TUTORIAL INSTRUCTION

Audio-tutorial instruction has been adequately reviewed in the previous chapter on audio research, however, a brief summary of the research findings is warranted here. Audio-Tutorial instruction had its origins with S. N. Postlethwait who in 1961 first combined audio tapes and individualized instruction to develop a self-paced approach to teaching introductory college biology courses (Postlethwait 1963). Since that time the audio-tutorial method has been adapted and tested in many other settings including elementary and secondary schools (Kahle 1978).

Results of numerous research studies seem to indicate that audio-tutorial instruction is nearly always equal to or better than lecture/laboratory instruction and that student attitudes toward audio-tutorial instruction tend to be positive (Fisher 1976; Kahle 1978). The effectiveness of audio-tutorial instruction in elementary and secondary schools is less clear, however, the findings seem to support the findings for effectiveness of audio-tutorial instruction at the college level for science instruction.

INDIVIDUALIZED INSTRUCITON

Educators have advocated individualized instruction in the classroom for a number of years, but have done little to implement it in practice. Most efforts have concentrated on having students work at their own pace and giving additional attention to students who seem to need it (Wittich and Schuller 1979). Instruction may be classified as individualized if experiences are specifically designed for each individual student taking into account background, knowledge, experience, ability level, interests, etc. There have been several attempts at individualizing instruction which have tried to allow for individual needs of students in the instructional design. In a review of such studies Ramsey and Howe (1969) conclude that individualized instruction is a viable alternative to class instruction. Even very young children can work alone on preplanned experiences using quite sophisticated aids with minimal teacher help. However, they go on to suggest that each child should have the opportunity to develop science concepts and skills in both individual and group situations. The outcome of one kind of instruction will complement rather than parallel the other.

Royce and Shank (1975) reviewed 21 research articles comparing individualized methods with traditional group-paced instruction between 1967 and 1974. They found that student achievement of cognitive objectives were equal in either setting. Similarly, there were no significant differences in critical thinking ability or in inquiry skills. There were, however, some indication of differences in achievement measuring understanding of science with two reports showing significant gains by the individualized classes. Some studies reported student feelings of isolation and boredom while one study concluded that students in individualized classes missed an important part of their education, that is, social contact with peers.

The following selected studies on the effectiveness of individualized science instruction are typical of those found in the literature.

> Baum (1965) tested the feasibility of individualized instruction in science for fifth graders. He devised a series of pretests of skills and knowledge so that student deficiencies could be identified. Each student was then assigned a kit specifically designed to help him acquire the skill identified as deficient. The method was found suitable. Evaluation was carried out by observing students' reactions to instruction.
>
> O'Toole (1968) compared an individualized method with a teacher centered approach in teaching science to fifth graders. He found no significant differences in achievement, problem solving ability, or science interest. The teacher centered approach stressing problem solving was more effective in developing the ability to identify valid conclusions. The individualized approach was more effective in developing the ability to recognize hypotheses and problems.

It seems likely that group methods of instruction will develop some outcomes more effectively than individualized methods, while other outcomes will develop more effectively in an individualized situation. This supports the findings of Ramsey and Howe (1969).

> Heffernan (1973) compared the effects of two methods of science instruction, individualized and traditional. Eighth grade students (104) were randomly assigned into groups using the Solomon Four Group Design. 26 were assigned pre- and posttests from the experimental group, 26 received posttest only. 26 control group students were assigned pre- and posttests, while 26 received posttests only. Instruments indluced TOUS Form W Scale 1, TOUS Form W Scale 2, TOUS Form W Scale 3, Form Ym of the Watson Glaser Critical Thinking Appraisal, and the Science Attitude Survey. All 104 students were taught by the same teacher. Results showed no significant differences in mean scores of experimental and control groups on TOUS Scales 1, 2, or 3. There were no significant differences in mean scores on the Watson Glaser Critical Thinking Appraisal or the Student Attitude Survey.

The Heffernan study indicated evidence of teacher "leak". That is, the teacher may have increased group activitiy in the individualized classes due to its apparent success in the traditional classroom.

> Reed (1974) examined student achievement, attitude toward science and self concept of ninth grade physical science students in an individualized science program and in a tradtional science class. The sample was 150 experimental students enrolled in an individualized class and 150 ninth grade students in a traditional class. A posttest only control group design was used. Instruments included the Stanford Achievement Test - Science, Remmer's Attitude Toward Any School Subject Scale, and the Piers-Harris Children's Self Concept Scale. Conclusions were 1) physical science students in the individualized classes showed no significant difference in achievement from students in traditional classes, 2) there were no significant differences in attitude toward science

3) there were no significant differences in self concepts of students.

> Ramsay (1975) sought to determine if there is a relationship between the number of ISIS minicourses completed which contain the same cumulative objectives and achievement gain on a posttest and/or reading comprehension. Four high schools participated in the study with 396 students in 22 classes taught by eight science teachers. There was a relationship between a student's achievement on pre- and posttests measuring one cumulative objective and the number of minicourses completed. There was no relationship between a student's achievement on pre- and posttests measuring four cumulative objectives and the number of minicourses completed. A student's reading level does not determine achievement of the ISIS minicourse cumulative objectives.

Ramsay's study seems to indicate that repetition in individualized instruction should be used with caution. It appears that once learned repetition does not lead to significant achievement gains and thus may be a waste of student time and effectively inefficient. One may conclude then that such materials must not only be carefully crafted, but must also be carefully sequenced with proper options available once skills or concepts are attained.

> Sheehan and Hambleton (1977) compared four instructional strategies along with several student variables including student anxiety levels. 285 students in ninth grade science were randomly assigned to four treatment groups; 1) teacher directed treatment - teacher lecture, 2) media treatment - students worked alone or in pairs on worksheets used in conjunction with one video and seven audio tapes, 3) reading treatment - students read handout materials and worked alone, 4) programmed instruction - students worked alone on one set of five booklets of 185 frames of programmed material. Twelve tests were administered including a Module Achievement test immediately after the test period and again one month later and an anxiety scale. Though most results were unclear teacher directed treatment tended to be superior in student achievement gains. The performance of students in programmed instruction treatment is markedly affected by their anxiety scores. Less anxious students score much higher on the acheivement test than do highly anxious students.

Again it seems that individualized instruction is not appropriate for all students. Such factors as anxiety of students may well affect their ability to gain significantly using this learning approach.

From the studies on individualized instruction it seems that student achievement using this method may be equal to that of other instructional strategies. Further individualized instruction is equally effective in producing gains in critical thinking skills and in developing inquiry skills. It also seems clear that individualized instruction should not be the exclusive mode of instruction, but is most effective when used in combination with other instructional strategies. If trully individualized instruction is to take place care must also be taken to match appropriate strategies to individual needs. Such factors as anxiety levels and ability levels may indeed affect performance more than the instructional strategy used.

PROGRAMMED INSTRUCTION

The role of programmed instruction in schools has had considerable attention from researchers particularly since such programs encourage individual student work, and free the teacher from direct instruction to perform other tasks. Ramsey and Howe (1969) concluded from their review of programmed science instruction that elementary students can learn from programmed instruction. Learning outcomes are further enhanced when programmed instruction is integrated with laboratory experiences.

Programmed Instruction vs Traditional Instruction

The following studies compared the effectiveness of programmed and tradtional instruction.

> Nasca (1964) conducted an evaluation of three methods of presenting science laboratory materials. Five experiments with eighth grade students were conducted to evaluate temporal relationships between the methods and the effectiveness of the methods. Measures of ability to solve work and energy problems were obtained from subjects who observed, read, or received only programmed instruction with laboratory experience. All methods produced significant gains. Multigroup comparisons by analysis of covariance showed that effectiveness of procedures used was highly dependent upon the testing instruments used. No significant difference among the methods was observed.
>
> McKee (1966) investigated whether a combination of conventional and programmed instruction was more effective than conventional instruction alone in teaching ninth grade physical science. Three treatment groups were 1) conventiional instruction, 2) programmed instruction used to initiate instruction and 3) programmed materials used to review assignments. The criterion referenced test administered as both a pre- and posttest was divided into two parts, recall and application. Twenty three intact classes (547 students) were randomly assigned to the treatment groups. Results showed no significant difference between the three adjusted gain scores of the treatment groups. There was no significant difference between the gain scores of the five teacher groups. Further, students tended to become tired of the programmed materials toward the end of the unit, however, the majority felt that the programmed materials had helped them and they expressed a desire to use them again.

Carnes, Bledsoe, and Vandeventer (1967) compared the effectiveness of a nonprogrammed, problem solving method of teaching seventh grade science and that of a programmed, problem solving approach through selected, open-ended laboratory experiences. In the experimental sections (n = 106) teachers were instructed not to use any materials other than the programmed laboratory materials. The control groups (n = 115) received instruction in the same content as the experimental group, but with no programmed materials. A criterion referenced test was administered as a pre- and posttest along with the Kuder General Interest Survey. Results showed 1) students achieved significantly higher factual science knowledge from nonprogrammed materials, 2) students achieved significantly higher conceptual science subject matter from nonprogrammed instruction and 3) there was no significant difference in change in interest in science using either approach.

Eshleman (1967) measured the effectiveness of programmed instruction in comparison with conventional methods in teaching factual information in eighth grade science. Twelve classes of over 300 students were divided into 1) six experimental classes which studied a two week unit on the solar system using a commercially produced programmed text and 2) six control classes which studied the same subject matter by conventional means. Later in the school year the groups were reversed for a two week unit on cells. Results showed 1) both methods produced significant gains in factual knowledge both immediately and after a six week period, 2) the conventional group scored significantly higher than the programmed instruction group on both immediate testing and on retention testing, 3) there were no significant differences between above average ability subgroups for both immediate and retention tests, 4) there were no significant differences between below average ability groups for retention tests.

Both these studies indicate superior achievement for students in conventional classrooms. Both studies appear well designed and include reasonable controls for intervening variables. However, other studies do not show consistent results.

Darnowski (1968) compared learning and retention of principles of nuclear chemistry in a high school chemistry course using three forms of programmed materials and the conventional lecture/demonstration method. Students who participated in the study were assigned to 4 groups each with 26 students. Three experimental groups were identified 1) linear short step 2) linear long step and 3) branched programmed instruction. The long step form deleted repetitious practice and review frames while the branced form allowed students who correctly answered the key test items to skip over the repetitious frames. During the study, experimental programs were administered by the regular teacher. Results indicated that 1) all groups learned a significant amount, 2) the programmed groups as a whole gained significantly more than the conventional group, 3) the control group had a significantly greater retention of facts and principles after a two month period, and 4) the branched group learned significantly more than the control group.

Darnowski's study raises questions about the appropriate use of programmed instruction. Perhaps used in selected ways it can produce significantly greater effects. Further, it may be more appropriate at higher grade levels where students are more mature and more responsible for their learning and behavior. It can also be assumed that Darnowski dealt with above average students since only such students tend to take high school chemistry.

> Moriber (1969) tested the effectiveness of a three week programmed unit in atomic theory and chemical bonding against the conventional lecture/demonstration method in a physical science course for nonscience college majors. The programmed unit was administered to 120 students. Another 120 students served as controls receiving regular lectures. Results indicated that the programmed unit produced significantly greater gains in knowledge as measured by criterion referenced tests.
>
> Strickland (1972) compared the achievement of junior college biology students taught by programmed vs lecture methods. The experimental group used programmed materials while the control group used the regular text. Pre- and posttests were administered. Results showed that students using the programmed materials improved significantly more on the achievement test than did the control group. Neither method seemed to affect critical thinking skills or to affect motivation.
>
> Flowers (1977) investigated the comparative effectiveness of programmed instruction with teacher centered instruction. 175 eighth grade students were involved in the semester study. Both programmed and conventionally instructed students increased skills in comprehending weather and climate. There was no significant difference between the treatment groups in achievement. Flowers suggested that optimum learning would result from a combination of approaches.

From these studies it appears that for intermediate or middle school students programmed instruction is just as effective as conventional instruction in science. At the high school or college level programmed instruction may in fact be more effective than conventional lecture approaches. It is also clear that a combination of instructional strategies is most effective in increasing student cognitive gains.

Attitudinal Studies Using Programmed Instruction

Several researchers have investigated the effect of programmed instruction in science on attitudes of students. A few of the these are reviewed in this section.

> Taylor (1965) took 89 fourth grade students who used programmed materials for 4 months and 16 fourth grade teachers. Analysis of the relationship of selected teacher personality characteristics toward programmed instruction was conducted. Teacher attitudes toward programmed instruction were correlated with with student attitudes. Teacher attitudes did not correspond to varied student attitudes. Teachers accounted for 18% of the variance in predicted student achievement while student personality accounted for 46% of the predicted student achievement.
>
> Frey (1967) studied 74 eighth graders enrolled in a general science class to determine attitude changes related to instructional methods. Students were divided into four classes all taught by the same teacher. The methods of utilizing programmed materials were varied by two dimensions 1) in or out of class use and 2) teacher or student regulated scheduling of rate of progress

> through the materials. Findings revealed that the total group dropped in its attitude toward programmed instruction during the second semester and that this drop was statistically significant. There was also a marked decline in achievement. It was concluded that 1) the continued intensive use of programmed instruction over an extended period of time without relief through other modes of instruction is not recommended and 2) the problem of motivation for classroom learning is perhaps the most persistent of formal education and that programmed instruction does not appear to address this problem.

Attitudes toward programmed instruction vary with students being more favorably disposed to it than teachers. Students soon become bored with programmed instruction and seek relief through other means of learning. These studies support those reviewed earlier in this chapter favoring a combination of instructional strategies for optimum learning and motivation.

Effect of Intervening Variables on Effectiveness of Programmed Instruction

As with any instructional strategy intervening variables have differential effects on outcomes. A significant number of studies have investigated student, teacher, and school factors which may affect the impact of programmed instruction.

> Taylor (1960) investigated the effect of pupil behavior and characteristics and teacher attitudes on achievement when programmed science materials are used at the fourth grade level. Teacher attitudes, combinations of student and teacher attitudes, student intelligence, interest, and initial knowledge of science, along with other selected personality and performance factors all contribute significantly to student final achievement. The study indicates that any given set of programmed science materials cannot meet the needs of all students at any given grade level.
>
> Blank (1963) investigated developing inquiry skills through programmed instruction. The programs trained students to ask questions about the relative dimensions of problems before attempting to solve them. He found that students given inquiry training asked significantly more questions on oral and written criterion tests than did students in control groups. This improvement in inquiry skills was not at the expense of other achievement criteria.
>
> Dutton (1963) investigated student achievement using programmed materials on heat, light, and sound with fourth graders. He found that students did proceed at different rates and that they could perform simple science experiments with little teacher supervision. Pupils using programmed materials learned concepts more efficiently than students taught by conventional methods.
>
> Fleming (1963) conducted a comparative experiment between conventional and programmed use of educational film with seventh grade science students. Approximately 400 students from 5 schools were involved in the experiment. A posttest and retention test were used to measure achievement. Findings indicated that programmed use of film resulted in significantly greater achievement and retention than just showing the film and that programmed instruction was an effective way of increasing attention.

Crabtree (1967) studied the relationship between score, IQ, and reading level of fourth grade students by structuring programmed science materials in different ways. Linear programs seemed preferable to branched versions since the same amount of material was learned in less time. Other findings were of the no significant difference type.

Note that Crabtree's results are at odds with those of Darnowski (1968) who found that branched versions were significantly more effective in effecting achievement gains in chemistry than other structures. This may be due to differences in age or even ability levels rather than actual effects of differences in structure.

Filep (1969) conducted three experiments on the use of programmed learning to teach general science to eighth grade students. Three visual stimulus modes and three audio stimulus modes were used with either linear or branching programs. Subject content was nonconcrete, concrete, or action process. Learner characteristics treated as independent variables were IQ, sex, achievement, ethnic background, parent's occupation, and apptitude. Automated teaching devices were used which incorporated both filmstrips and slides. Data collected on amount learned were analyzed. IQ score was found to be the best predictor of achievement. Ethnic background accounted for only a small portion of the total variance. A positive correlation was found between achievement and parent's occupation. No sex differences were found. Disadvantaged children learned best with the branching, nonverbal, sound treatments.

Not only has Filep identified significant intervening variables particularly IQ and parent occupation, but he has also shown that treatment effects are different for different students. Such findings certainly compounds the problem of preparing programmed instructional materials. It indicates that only a highly skilled teacher who has intimate knowledge of each student can successfully prepare the right combination of instructional materials for optimum learning.

Awkerman (1969) compared an auto-instructional program on the process of measurement in which the control group of 158 fourth and sixth grade students worked alone with an experimental group in which fourth grade students (169) were randomly paired with sixth grade students. High, medium, and low reading levels were ranked. The paired students were asked to discuss and assist each other with frames answered incorrectly. Results showed no significant difference in treatment on the achievement or self concept measures. The experimental group required a significantly longer completion time.

O'Reilly (1969) investigated anxiety, creativity, and intelligence factors in relationship to programmed instruction. He chose 80 boys and 85 girls in nine sixth grade classes. An additional 40 boys and 37 girls in four sixth grade classes served as controls. The program suggested that verbal IQ and pretest would have little or no relationship to achievement when the programmed materials were used with appropriate selected learners. Subjects received 10 lessons using a linearly constructed response program. The results showed that none of the creativity variables or the interactions contributed significantly to achievement.

> Marshall (1970) tested the effectiveness of a programmed text used in conjunction with regular classroom instruction in four tenth grade biology classes. Students were of three different ability levels. Each group was divided into two groups 1) experimental group using the programmed text to review class instruction, and 2) control group given conventional assignments. Significant differences were found among students of different ability levels. High achievers (IQ) were the highest performers. Low achievers performed at lower levels and made smaller gains. Control and experimental groups showed no significant differences in gain scores, midterm examinations, or final examinations. No significant differences were found on the basis of six week grades. Experimental students did, however, complete a significantly higher percentage of assignments. Students using the programmed materials indicated that they liked them.

Marshall's study sheds some doubt on the effectiveness of combinations of programmed materials with other modes of instruction. His study is limited in scope and in the particular way in which the materials were used. As noted earlier others have indicated that combinations of instructional techniques lead to better student performance.

> Fryar (1971) defined underachievers as students with IQ scores of 90 or above whose performance on standardized achievement tests had been at least a full year below grade level. 236 students were randomly assigned to an experimental or control class in four junior high schools. Programmed materials were used in the experimental group. For two of the four units studied gain scores were significantly higher in the experimental group. Findings suggest that underachievers interacting with programmed materials exhibit greater achievement gains than by using conventional materials.

Several studies have researched the effects of pacing of programmed materials on achievement. The following are examples.

> Kress and Gropper (1964) presented programmed lessons in science over television to eighth grade students. Twelve separate versions were compared including three versions differing in prompting strength and with each of these versions presented at four different tempos. Comparisons were made among treatments. Results provide tentative support for involving multiple program sources to accomodate individual differences during fixed pace instruction. Added prompting technique reduced error rates but led to lower achievement. In order to learn effectively, slow learners require slow, fixed pace. The imposition of the same pace on fast workers results in a drop in effectiveness as well as learning efficiency. Findings suggest that the need for at least two program sources delivered at different rates is desireable.

Kress and Gropper further report (1964) that the pace at which a student works on a program can be nonadaptive whether it is self paced or externally paced. It can be too fast to be compatible with high achievement or it can be too slow to be compatible with learning efficiency. Individualization of instruction can be best attained by a pacing strategy that can maximize learning effectiveness and

and efficiency.

Programmed instruction, then, is generally equally effective as conventional instruction but should be used with caution. Overuse may result in lack of interest, motivation, boredom, and lowering of achievement. Several variables have been found to have effects on achievement using programmed materials. These include different learning rates, differences in ability levels, parent's occupation, and pacing. Programmed instruction apparently can also be used to develop inquiry skills and can be an effective way of increasing attention to tasks in class.

COMPUTER ASSISTED INSTRUCTION

Wittich and Schuller (1979) identify four legitimate instructional uses for computers, drill and practice, tutorial uses, simulations and games, and information handling aids. Feldhusen (1969) notes that there are some things which CAI is able to do better than other media: 1) secure, store and process information about a student's performance prior to and/or during instruction, 2) store large amounts of information and make them available more rapidly than other media, 3) provide programmed control over other media, 4) provide a convenient way of designing and developing a course of instruction, and 5) provide a dynamic interaction between student and program.

Zinn (1979) has attempted to summarize the research on computers in science education but points out that virtually all of these use a technology or approach which is now obsolete. In previous studies computer time has been valued more highly than student time but with the advance of handheld calculators and micro processors this is no longer the case. Zinn identifies six roles for the computer in science education; delivery system, assessment tool, management aid, development system, study aid, and research tool.

Keeping in mind that the technology used in research on the use of computers in instruction is now obsolete, the following investigations indicate the general findings of such studies and the basis from which new studies will begin.

Dasenbrock (1970) investigated the validity of the use of CAI as a tool in formative curriculum evaluation. A comparison of student performance using the ISCS program in CAI and nonCAI classes was made. The CAI student sample consisted of 20 students. The nonCAI sample of 40 students were selected so as to match the experimental group by ability levels. The California Test of Mental Maturity, Metropolitan Achievement Test-Reading, and the Lincoln-Oseretsky Test of Motor Proficiency were given. Results indicate that CAI and nonCAI student performance was similar.

Arsenty and Kieffer (1971) reported on a study of the teaching effectiveness of CAI using the PLATO system in first level biology courses at the University of Illinois. At the conclusion of the study data indicated that PLATO had the potential to become an effective adjunct by 1) increasing student comprehension of lesson material, 2) actively engaging students in learning processes, 3) significantly reducing the amount of time spent on lessons, and 4) contributing to higher examination scores.

Summerlin (1973) examined the degree of retention of materials presented in chemistry after a sixty day period between those students receiving their instruction via CAI and those receiving instruction in the same topics using more traditional methods of instruction. A total of 110 high school students were randomly selected to participate in the study. 58 were assigned to the experimental CAI group, 52 were assigned to the control group. The experimental group received tutorial type CAI and the control group received lecture/demonstration. Posttests and retention tests showed that learning and retention were higher in the control group, however, the CAI produced faster learning, more student interest in and better attitudes toward science.

Though studies similar to these seem to indicate no or little difference in learning outcomes there may, in fact, be effects related to efficiency, attitudes and interest.

Lasater (1971) evaluated a CAI program involving applications of chemical principles. The development utilized a systems approach and included specification of the terminal behavior and of entering skills, a description of intermediate objectives and their arrangement into a learning heirarchy, and the development of an instructional sequence. It was concluded that the program performed satisfactorily with respect to increased student ability to demonstrate the desired terminal behaviors and with respect to individualized instruction. The post program achievement of the terminal behavior seemed to be inversely proportional to program path length.

Gardner (1971) conducted a study to determine the relationship between psychological readiness and achievement on a CAI program for science teacher education. The teaching skill selected was the identification and use of behavioral objectives. The range for teaching experience was from 0 to 36 years. The subjects participated in a CAI science program. Results indicated that students were generally successful in learning the identification and use of objectives taught by CAI.

Thomson (1971) explored the use of computer simulated experiments as a tool to diagnose elements of propositional thinking in cognitive functioning in intermediate school age students. The study was built upon the following: 1) the cognitive role is an important function of the school, 2) the intermediate school student science experience is largely propositional thinking, 3) cognitive functioning proceeds toward formal operations, 4) experiments using scientific methodology requires elements of propositional thinking, 5) there is a need to diagnose stages of cognitive development and 6) the capabilities of the computer and computer simulated experiments for propositional diagnostic purposes is realistic.

Similarly, Liao (1971) examined the effectiveness of analog computer simulation as a pedogogical tool for learning intellectual abilities and skills. Thirty six students participated in the study. While all subjects were studying model concepts and skills in class, the investigator met individually with each member of the analog and science activity groups four times. He found no significant difference in posttest achievement scores.

Lunetta and Blick (1973) evaluated a series of computer based dialogs in introductory physics. The simulations paralleled the inductive experiments developed by the PSSC through which Newton's Second Law could be generalized. Three treatments were used. 1) Group 1 (n = 51) interacted with only the film loops developed in the study and with computer interactive dialogs, 2) Group 2 (n = 41) did not have computer access and interacted with the filmloops and simulated data and problem sheets prepared from the computer lessons, 3) Group 3 interacted only with their teachers and laboratory materials. Results after 3 month's treatment indicated that 1) learning of concepts was significantly greater for group 1, 2) students in group 3 spent 8.3 times as long in instructional unit activities as did students in groups 1 and 2, 3) group 2 exhibited a conceptual loss on a 6 month retention test while group 3 showed no significant loss, and 4) group 1 and 2 showed favorable attitudes toward simulated units.

Lunetta and Blick provide some stimulating data on the effectiveness of CAI simulations especially in light of increasing costs of laboratory equipment and supplies. With computer costs reaching reasonable levels CAI may be able to take over some of the laboratory experience especially for dangerous or expensive experiments.

Hughes (1974) assessed the effect of computer simulated experiments on attainment of process skills and acquisition of subject content in high school physics. 51 students from 2 high schools were randomly assigned to one of three groups, 1) a lab group which performed experiments, collected data and analyzed it in the traditional manner, 2) a lab/computer group which set up experiments performed one trial to collect sample data, but then used computer simulations to obtain data for analysis, and 3) a computer group which had instruction sheets which described the experiment but used the computer exclusively to derive their data. Results showed that both computer groups scored higher than the lab group. The lab/computer group had the highest mean scores on the content examination. The lab/computer group and lab group had higher mean process skill test scores but not at a significant level.. The computer group performed more trials than the lab group and required more time to finish. The lab/computer group showed more favorable attitudes toward the computer than the computer group.

> Hazen (1974) compared the effectiveness of an innovative simulation game to traditional question and answer teaching. Effectiveness was measured in terms of immediate cognitive gains and retention of cognitive learning. A nonequivalent group design was used with four intact tenth grade biology classes in two schools (n = 116). Classes were randomly assigned to experimental and control groups. The design involved a pretest, a 4 day unit, posttest, and retention test given 3 weeks later. Content of the classes was the same. The experimental group played a simulation game with daily 15 minute debriefing sessions. The control group used more traditional instruction including movies, question and answer, and discussion. Results showed no significant difference on immediate cognitive learning. A significant difference was found on retention favoring the simulation group. Student attitudes toward gaming was not significantly related to posttest scores but was significantly related to retention scores.

It seems clear from these studies that CAI simulation is an effective means of providing laboratory experiences at least vicariously. It is equally clear that combinations of techniques result in higher achievement.

> Culp (1975) developed and tested 32 CAI lessons in organic chemistry. The modules were designed as supplements to the traditional course and emphasized tutorial drill and experiment simulation applications in some of the basic organic chemistry concepts. No significant differences were found in achievement between students using the CAI and those who did not.

> Barnes (1976) investigated the role of learner controlled instruction in CAI. Using multiplication as the vehicle she looked at the effect of allowing the learner to determine the type of feedback desired. A CAI drill and practice program was written consisting of 5 types of problems. 68 subjects in grades 4 - 8 were randomly assigned to six treatment combinations. Results showed no significant differnece among the treatment conditions.

> Staniskis (1977) compared biology test scores between 42 junior high school students taking a computerized biology course and 31 students in senior high school taking a non computerized course. The computer instructed junior high group scored significantly higher on posttest achievement than students in the non computer course.

> Knight and Dunkleberger (1977) sought to determine the influence of computer managed self paced instruction on student attitudes toward science. Students experiencing computer managed self paced instruction were compared with counterparts in a traditional group paced teacher managed classroom. Subjects were ninth graders enrolled in a one year physical science course. 46 students participated in the computer managed classes, 48 in the regular class instruction. Computer managed self paced students achieved significantly more positive attitudes toward science than students in the conventional class instruction.

Results of research on CAI indicate that it is an effective instructional medium for science. Given the advances in new technologies, lower costs, and the advent of home use of computers it is reasonable to expect that research findings using today's available computers may result in even greater effectiveness.

SUMMARY

This chapter has reviewed the literature on research on programmed learning including audio-tutorial instruction, individualized instruction, programmed instruction, and computer assisted instruction. As concluded in the previous chapter audio-tutorial instruction is nearly always equal to or better than lecture/demonstration in gains in student achievement in science and that attitudes toward audio-tutorial instruction tend to be positive (Fisher 1976; Kahle 1978).

The research on individualized instruction indicated that little has been done though there has been ample talk in educational circles about the desirability of the technique. Reviews of the literature by Ramsey and Howe (1969) and by Royce and Shank (1975) show no significant differences in student achievement in either individualized or group paced traditional instruction in science. Heffernan (1973) found no significant differences in students critical thinking abilities or attitudes between individualized and traditional modes of instruction. These conclusions are supported by Reed (1974) and Ramsey (1974). Research studies also indicate that individualized instruction should not be the exclusive mode of instruction, but is most effective when used in combination with other strategies (Ramsey and Howe 1969; O'Toole 1968). This is perhaps because no one strategy is effective with all students. Sheehan and Hambleton (1977) for example have demonstrated that anxiety levels of students determine to a great extent the effectiveness of an instructional strategy.

Programmed instruction has received considerable attention since it appeals to those who desire individualized approaches which free teachers to attend to other tasks. Studies comparing the effectiveness of programmed instruction with traditional instruction indicate that students can learn as effectively by this technique (Ramsey and Howe 1969; Nasca 1964; McKee 1966). Carnes, Bledsoe, and Vandeventer (1967) and Eshleman (1967) demonstrated superiority of programmed instruction over traditional instruction. Other studies (Darnowski 1968; Moriber 1969; Strickland 1972; and Flowers 1977) seem to indicate that programmed instruction may be more appropriate for students in high school or college than for students in elementary or middle school.

Students tend to have favorable attitudes toward programmed instruction (Taylor 1965; Frey 1967) while teachers are less disposed to the technique (Taylor 1965). IQ and parent's occupation may be related to success in programmed instruction (Filep 1969) and ability level may also affect usage. Fryar (1971) has indicated that low achievers may be able to make substantial gains using programmed instruction. Pacing of programmed materials is another area of contention. Pacing should be adjusted to the learner's rate of learning (Kress and Gropper 1964).

Most studies on computer assisted instruction are obsolete due to newly emerging technologies (Zinn 1979). As with other types of media CAI seems to be as effective as traditional instructional strategies (Dasenbrock 1970; Arsenty and Kieffer 1971; Summerlin 1973). Lunetta and Blick (1973) indicate that CAI may be used in place of expensive or dangerous labs in science. This is supported by Hughes (1974) and Hazen (1974). Most studies indicate that CAI is as effective and in some cases more effective than traditional modes of instruction.

CONCLUSION

Programmed learning is an effective means of instruction in science. It is capable of attending to some student needs, however, to be optimally effective must be developed and programmed by a teacher who knows each student intimately. This is a rare occurance. Consequently, programmed instruction will probably continue to be on the fringes of instructional techniques. Teachers as yet do not have the time or the skills to prepare such programs. Commercially available programs do not meet class or individual needs. Further, teaching machines tend to threaten teachers confidence in their own classrooms.

It seems clear that the most effective means of instruction is to combine media, lecture, demonstration, laboratory, programmed instruction, and computer assisted instruction to maximize the opportunities for students to learn. No two students will learn a concept or skill in exactly the same way. By providing a combination of educational opportunities teachers can better insure successful learning outcomes.

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Chapter 5

VISUAL

EDUCATIONAL COMMUNICATIONS AND TECHNOLOGY AS APPLIED TO SCIENCE EDUCATION IN INTERMEDIATE/MIDDLE SCHOOL

VISUAL

INTRODUCTION

This final chapter overviews the research on visuals in science education. These include pictures, graphics, kits, realia, three dimensional models, displays, maps and globes, community study and field trips, and overhead transparencies. Wittich and Schuller (1979) pointed out that "the most difficult skills for designers of visuals to learn is to define what they wish to convey and then control the medium so that the message gets across." They have also extensively described the wide variety of visuals. The following is summarized from their text.

Flat Pictures - The advantages of flat pictures is their low cost, ready availability, and ease of use. However, they are limited by their small size making them difficult to use for class instruction and by their lack of depth resulting in perceptual and spatial relationship difficulties for students. To be effective pictures must have good composition, a clear center of interest, good contrast and sharpness and should communicate a single idea clearly. Color adds realism as well as attractiveness to this visual medium.

Graphics - These are instructional materials that summarize information and ideas through drawings, words, symbols and pictures. Their instructional value generally lies in their capacity to focus attention and to convey certain types of information in a condensed form. Graphs are commonly used in science instruction. A graph is a visual representation of numerical data which reveals important relationships among data.

Diagrams - Diagrams are also used extensively in science. These are drawings using lines and symbols that show outlines, interrelationships, or key features of a process, object, or area. Those used in science can be highly abstract and complex.

Charts - Charts are visual summaries containing a mix of visual and verbal cues. They may summarize data, explain processes, or describe relationships. Charts include tabular charts, flow charts, and time line charts. Good charts have a single clearly defined purpose and the information is in summary form which is easily readable.

Cartoons - Specifically, cartoons are satirical drawings designed to influence opinion. A comic is a form of cartoon acting out a story in pictures. Instructional comics are increasingly being used in science texts.

Model - Models are recognizable three dimensional likenesses of the real thing. Models may represent something very large or very small. They are effective teaching devices because they are three dimensional, they can show large or small objects in detail, they can simplify complex objects, and they can accent important features.

Specimens - Often used in science, specimens are representatives of groups of classes. They are better than models because they are the real thing. Specimens are more authentic, concrete, realistic. They include such things as frogs, insects, rocks, etc.

Out-of-door Field Trips including Museums - These are often used in science and though enormously popular few have stopped to analyze why (Koran and Baker 1979). Outdoor laboratories are areas on or adjacent to the school campus often referred to as a class study area. Museums offer unique learning opportunities particularly with recent efforts at providing interactive experiences for visitors. Museums exhibit the real thing, a diorama of a natural environment, or a skeleton of a prehistoric animal, all of which are difficult, if not impossible, to provide in the science classroom (Watson 1978).

The remainder of this chapter reviews the research on visual media use. Sections include comparison studies on the use of visuals, studies on pictorials, intervening variables effect on visual instruction, models, and field trips and museums.

COMPARISON STUDIES ON VISUALS

The following eight studies attempted to compare the use of visual instruction with other modes of instruction.

> Koechel (1970) compared two methods of visual technique, single concept films and overhead projections in teaching college chemistry. The experiment was carried out over a two year period on four classes of chemistry students who were nonscience majors. Subjects were assigned to sections on a random basis. Lessons were constructed and validated for the lecture/discussion sessions in each of six areas. The same time was allotted to both experimental and control groups. Experimentals had visuals integrated into class presentation The same instructor taught all sections. Sections were alternated between treatment and control over the six areas taught. Results over two years showed differential effects by topic area. For single concept films results showed significant differences in favor of the treatment groups for two of the topics. Other topics did not result in any significant differences between treatments. Similar results were reported for the overhead projections. The author noted that though results seem to be topic related use of projections seemed to involve students to a greater degree.
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> Dwyer (1973) attempted to determine the most effective method of presenting visualized instruction and to establish guidelines which could be used to specify which methods are most effective in facilitating student achievement. Purposes were to determine the relative effectiveness of presenting visuals by TV, slides, or programmed instruction used to complement verbal instruction; to determine whether the same types of visuals viewed by the three presentation formats were equally effective. Findings showed that the effectiveness of visuals depends upon the 1) subject matter and 2) the method of presentation.

Both these studies show that as with other media visuals are no panaceas. Some media works better for some students and subject areas than others. It seems clear from previous reviews in this overview that combinations of instruction are most appropriate and most effective taking into account differences in student abilities and interests as well as subject area.

> Well, Modfrans, Postlethwait, and Butler (1973) conducted a study to generate information about the effects on learning of presenting visual concepts via different media. The visual concepts were the manipulation of time, space, and motion. Three visual media were sequentially still photographs, slides, and motion pictures. Results showed that certain visual media are more effective than others. Of the three motion pictures were most effective for presenting the topics on motion. Photographs and slides were more effective in presenting concepts of space. The report concludes that if media decisions at a specific level based on what is required to display the defining attributes of a concept are not possible, then decisions at the general level should be made on a basis other than pedagogical effectiveness. Perhaps availability, permanence, portability, or cost should be considered.

Well et.al. not only support the two previous studies, but specifically state that decisions on which media to use should be based on appropriateness to concept. Where this is not feasible decisions probably should be based on factors other than effectiveness since much of the research suggests that there are few significant differences between modes in terms of outcome effectiveness.

> Kauffman and Dwyer (1974) designed an experiment to determine the relative effectiveness of different types of visual illustrations used to complement instruction in an inservice training program. Subjects were 179 students and employees from Pennsylvania State University and neighboring schools and hospitals. Results indicated that generally cartoons are more effective than realistic photographs in facilitating achievement on immediate and delayed retention tests. Subjects in three experimental groups indicated that they learned more from cartoon presentation and preferred them over photographs.

Results such as this may explain the recent increase in use of comics in middle school science texts. In general well drawn comics, cartoons, and diagrams would be expected to be more effective than photographs since line drawings can focus attention on important details. Photographs, on the other hand, contain significant amounts of irrelevant visual information for the performance of science tasks or the understanding of science concepts.

> Coulter, Adler, and Byrd (1975) conducted a study at East Carolina University to attempt to combat low enrollments in physics classes. A multimedia program was developed including demonstrations, transparencies single concept film loops, and sound films. Four classes were taught by the new method. Only one class showed a positive attitude change toward the course and multimedia. The authors hypothesized that this was due to the professor's strong advocacy of the multimedia approach.

Coulter et. al. introduce a commonly overlooked factor in the success or failure of a new instructional approach, the teacher. The two other professors involved in this study opposed the change from the beginning and were successful in showing that it was not effective. It appears that the teacher's attitudes strongly influence both effectiveness of programs and attitudes of students.

> Janoscrat (1976) conducted an investigation of individualization as it relates to the relationship of learner stated preference for mode of information presentation and subsequent performance, the instructional effectiveness of 2 different modes of visual presentation and their combination, and the interrelationship between stated preference, mode of presentation, and performance. The task was preparation of a medication. The visual modes were black and

white line drawings, printed words that were composed to be equivalent to the drawings, and a combination of the two. The population was 178 nursing students ranging in age from 16 to 54. Subjects were assigned to treatment groups according to their stated preferences for one of the three visual presentations. The analyses showed that preference had no effect on learning time or task performance time and no relationship to error rate. The type of instruction effected learning time. Learning time for subjects who received visual aids was significantly lower. Presentation mode had a stronger correlation to performance than did preference.

Dwyer (1976) reviewed visualized instruction. Some of his conclusions were that the use of visuals disigned to complement printed instructions does not automatically improve student achievement. It depends upon the educational objective. The visual most effective in transmitting information is dependent upon the type of information to be tranmitted, the amount of time students are allowed to interact with the visualized instruction, and sometimes the use of color. Boys and girls at the same grade level in high school learn equally well from visuals. Increasing the size of visuals by projecting them does not improve achievement.

Fuller (1977) assessed the influence of source of data, reading performance, and gender of third grade science students on science concept attainment and retention. Three treatments were used, overhead projections, booklets, and jigsaw puzzles to reassemble and flash cards to arrange. Third grade students (n = 133, 71 boys and 62 girls) from five classes in two elementary schools were randomly blocked into the three treatments. Immediately following one week of instruction, all subjects were administered a posttest of achievement and a delayed posttest of retention one week later. Results indicated that there was no significant difference in the three treatments. Reading performance did affect science achievement. There was no significant difference in retention by treatment group.

These studies on visual instruction seem to indicate that in general visuals are as effective as other modes of instruction, but may be more or less effective depending upon subject matter being transmitted. Ideally, teachers would be able to select and use the most appropriate media for transmitting information in a particular area effectively and efficiently. Realistically, however, teachers are not well prepared in the use of communication technologies and rely most heavily on existing science texts. One wonders how much research publishers do on the effectiveness of the many drawings, color photographs, cartoons, charts, etc. used in commercial texts. In most cases such texts are prepared to appeal to adult buyers rather than for the impact on learners.

STUDIES ON PICTORIALS

The following six studies focus primarily on the effectiveness of pictorials in science education.

> Weisberg (1969) examined the value of several modes of information organization to teach oceanography to eighth grade students. 96 students with little previous earth science background were assigned treatment groups. One group was exposed to a physiographic diagram of the ocean floor. A second group was exposed to a topographic profile. A third group read about the information. A fourth group acted as control and received no information. A pre- and posttest was given. Groups using the graphics did significantly better on the posttest than the reading or control group. There were no significant differences by sex.
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> Voelker (1973) conducted a study among sixth and seventh graders from average and low socio-economic neighborhoods in an urban, industrial community and fifth and sixth graders from a small combined agricultural-industrial community. The materials presented consisted of science concepts centered around an environmental problem with accompanying pictorials. Pre- and posttests indicated significantly better achievement in groups using the supplementary pictorials.
>
> Wardle (1975) investigated the predicted and actual contribution of science textbook illustrations to reading comprehension of students of varying reading ability. Two studies were conducted. The first focused on the actual learning value of illustrations. Thirty seven elementary teachers and 144 seventh grade students participated. Subjects rated the illustrations on a 1-10 scale indicated the degree to which the illustrations aided in understanding. There was significant disagreement between teachers and students. The second study investigated the number of test questions answered by an illustration related to its value in aiding the reading comprehension of students. 191 students participated in this study. Illustrations were selected from a pool used in Study 1. Students were randomly assigned to one of five treatments, 1) text accompanied by illustration which answered a high number of questions, 2) text accompanied by illustrations which answered a medium number of questions, 3) text accompanied by illustrations which answered a low number of questions, 4) an unillustrated text, and 5) control group without text. Students did not perform significantly better on reading comprehension tests when provided illustrations than without illustrations. No illustrations were found to aid reading comprehension.

Wardle's study supports conclusions reached earlier that illustrations in science texts are generally included by publishers to appeal to teachers and adults selecting texts rather than for their effectiveness in transmitting information. The disagreement between teachers and students in this study along with the major findings of no illustrations aiding comprehension indicates that selection criteria should be something other than the appeal of illustrations to teachers.

Thomas (1977) investigated four specific questions including the effect of including pictorials in written texts on reading comprehension of fourth graders. 108 fourth grade students from three elementary schools were divided into three achievement levels of high, medium, and low using the combined percentile scores from the SRA reading and science measures. Students were then randomly assigned to three treatments, color photographs with text, simple line drawings with text, and text only. Presentation was by slides. No significant differences were found among test groups. Pictures neither facilitated nor hindered reading comprehension.

Sherbo (1977) studied the effect of visual advance organizers on learning and retention of selected physics principles among 597 ninth graders in 24 classes. The ten teachers with intact classes were randomly assigned to either treatment or control groups. Treatment group consisted of 332 students who received visual advance organizers by overhead transparency. The control group consisted of 265 students who did not receive the transparencies. Results showed no significant differences in achievement between the groups. The results indicated to the author that teachers do not need to link prior learning to new learning to facilitate that learning.

Manzo (1977) examined imbedded aids which were defined as units of assistance and enrichment woven into the fabric of texts so as to be unobtrusive and yet present valuable information for the reader. 200 tenth grade students participated in the study. Half received instruction using imbedded aids, the other half received conventional texts. Results showed the imbedded aids group took longer to finish but scored slightly higher than the conventional text group. The imbedded aids were summarized as a good study and motivation aid providing additional information, but which did not result in significantly better achievement.

The studies on pictorials suggest the same conclusions as for visuals in general. They tend to be as effective as other modes of instruction and appear to appeal to adults using them in instruction. This criteria accounts for their widespread use rather than any evidence of the effectiveness with students.

INTERVENING VARIABLES EFFECT ON VISUAL INSTRUCTION

A number of studies relating to use of visual aids for instruction have focused on the interaction effects of other variables. This section will review some typical studies in this area.

Dwyer (1968) tested the interaction of visual illustrations and programmed instruction. 175 college freshmen were randomly assigned to one of nine groups. While verbal instruction was held constant, the amount of realistic detail contained in illustrations was varied from line drawings to color photographs of the objects. Results showed some visuals better than others. Black and white abstract drawings produced the best results on a drawing test. Those using color photographs were best able to identify component parts of the objects on an identification test. Those using no visuals performed best on terminology and comprehension.

Again we see that the outcomes desired are very important in determining which visual mode if any to be used in instruction.

> Moore and Sasse (1971) studied the effect of size and type of still projected pictures on immediate recall of content. A total of 228 students in grades 3, 7, and 11 were selected from heterogeneously grouped classes. All subjects viewed the same 9 pictures (paintings, line drawings, and photographs) on slides of varying sizes. The size of picture seen, order of presentation, and order of questions were randomized by class. Data showed that the size of pictures made a significant difference in amount of recall with small pictures (quarter screen) being least effective and medium size pictures being most effective. The type of picture also produced significant differences in recall, with line drawings producing higher results than paintings or photographs. Grade level also affected achievement. Seventh graders had the highest overall mean scores.

These results are in contrast to those of Dwyer (1976) who found no significant differences due to size of pictorials however, Dwyer was using still photographs not slides.

> Dwyer (1972) investigated the effect of overt responses in improving visually programmed science instruction. This study measured the relative effectiveness of eight types of visual illustrations designed to complement programmed instruction and determined the effect of color in visual illustrations as instructional variable in promoting achievement. The populations consisted of 266 students in a psychology class at Pennsylvania State University. Results showed that the simple line drawing with color was most effective in facilitating student achievement in drawing and a criterion test. The programmed presentation without visuals was found to be as effective as visually complemented treatment on the identification, terminology, and comprehension tests.

> Shulene (1972) studied the effect of pictorial riddles and corresponding inquiry procedures on educable mentally handicapped students in understanding science concepts. The sample was 45 students aged 7 to 16 enrolled in four classes. All classes were taught by the author. No reading or writing was required of the subjects. Pre- and posttests were used. Conclusions reached were that the pictorial riddles resulted in significant learning and is an effective method of teaching mentally handicapped students.

The results reported by Shulene indicate that the pictorial approach in science is an effective teaching technique for both boys and girls who fall in the IQ range identified as mentally handicapped.

> Holliday (1975) set out to test the effectiveness of instructional pictures as an adjunct to verbal instruction. Eighty students were randomly assigned to two treatments, verbal statement and pictures plus verbal statements. Pictures consisted of simple line drawings. The combination of verbal and pictures produced significantly better achievement gains than verbal alone.

> Berry (1975) conducted a study to compare the relative effectiveness of two forms of color cueing in visual instruction. Subjects were 224 college

> students in an instructional media course. They were divided into six groups each receiving the same oral presentation on the human heart. One group did not receive illustrations, one saw black and white drawings, two received realistic color drawings, two were given nonrealistic color drawings. All groups received immediate achievement tests and retention tests six weeks later. Data revealed that in those cases where instruction was accompanied by visual materials achievement was superior to no illustrations. Realistic color drawings were most effective in facilitating achievement. No significant differences were found, however, after 6 weeks.

Though the color drawings seemed to effect immediate superior achievement there are questions regarding long lasting effects. Color may be more appropriate for some instruction where color is used to identify key components and help students identify parts of objects.

> Dwyer (1976) also investigated color as a variable in visual instruction. 508 students at Pennsylvania State University were assigned to 8 treatment groups, simple line drawings black and white and color, detailed shaded drawing black and white and color, heart model black and white and color, and realistic photographs black and white and color. A 30 minute lesson on the heart was presented to each treatment group accompanied by the visual aids. Not all visuals were equally effective. The simple line drawing with color was found to be the most effective in facilitating student achievement.

> Holliday and Dahl (1976) tested the effectiveness of a lesson augmented by adjunct labeled drawings compared with a text presentation. Subjects were 61 ninth grade students in physical science randomly assigned to two groups. Group 1 used the text only. Group 2 used the text along with labeled, simplified, line-block drawings. Similar tests were administered to both groups. The drawing plus text group scored significantly higher than the the text only group.

> Tarcza (1976) tested the use of color photographs to reduce students' perceived difficulties in physical science laboratories. Students in a self-paced introductory physics course at the University of Maryland were divided into four treatment groups, laboratory guide no photographs, photo laboratory guide, preview (no photos) plus laboratory guide (no photos), and photo review plus photo laboratory guide. Photographs were in color. Students performed 11 experiments and rated their perceived difficulty in doing the tasks. Test population consisted of 27 students with a replication of 8 of the experiments by 29 other students the following semester. Incorporation of color photographs did not enable students to perceive the tasks as less difficult, however students with the photographs available sought assistance less frequently.

The research on color versus black and white is contradictory, but it seems that black and white line drawings are as effective as color drawings in most cases unless the color is used to focus attention on particular details. Drawings are nearly always superior to photographs in effecting higher student gains and in achieving greater student comprehension of science information.

Bunge (1976) investigated the use of hand motions to stimulate visual imagery in physical science instruction. The instructor traced imaginary figures in the air with hand motions while verbally describing the objects. Subjects were junior college students. One group watched and listened while another group listened only to the lessons. This basic design was repeated over two semesters. There were no significant differences between the means of the groups on achievement posttests.

Hill (1978) studied the relationship between visualization and performance in solving science problems. Subjects were 88 freshmen students in elementary teacher education in Australia. Students were randomly assigned to treatments one group receiving instruction in spatial visualization and the other with no such instruction. There was a significant correlation between subjects increased ability to deal with spatial relationships and their ability to solve science problems.

These two studies do not add especially to conclusions reached thus far on the use of visuals, but were the only studies found that deal with either variable. Teachers use hand motions often in describing science phenomena. Bunge has found that at least in his study they did not add to student understanding. On the other hand, one would expect that ability to deal successfully with spatial relationships would enhance student ability to interpret and make use of information transmitted visually.

THREE DIMENSIONAL MODELS

The following six studies deal with research on the use of three dimensional models in science instruction.

Goldberg (1965) attempted to determine the effect of three dimensional molecular models on the comprehension of students in high school chemistry. Eighteen intact chemistry classes were divided into two groups, one using colored three dimensional molecular models, the other using only the blackboard as a visual aid. The model group achieved significantly higher postest scores than the control group.

Model building both physical and mental is an important process in science education. The following study by DeVito investigated this aspect of general science instruction.

DeVito (1966) studied the contribution of certain science investigations to the understanding of the elements of scientific model building. 36 eighth grade general science classes consisting of about 1000 students participated in the study. They were divided into two groups. One group received instructional materials designed by the author which intended to develop student abilities to understand model building and the role of models in science. The other group did not receive such instruction but did receive the same content. Results showed that the treatment group had significant gains in understanding models and their uses over the control group.

Though this study does not investigate the actual use of models, it demonstrates that students on middle school age level can be successfully instructed on the use of models and can become more proficient in using models. This is perhaps true also of the other media. As educators we should consider including instruction in our lessons on how to use and interpret instructional media to optimize learning outcomes.

Dunstone (1972) used molecular models in college chemistry courses. 21 students in the test group made their own models of silicates. This required them to gather information on bond types, lengths, atom positions, etc. Results of the study are inconclusive due to the small number of subjects and the inadequacies of controls, but it does suggest a valuable learning experience for students.

Having students build models of structures under study may, in fact, be a most useful technique both to help students understand the three dimensional nature of objects and to evaluate and identify student difficulties in perceptions.

Barufaldi and Dietz (1975) investigated differences in visual perceptions of children using solid objects and two dimensional representations of the same objects. 228 students in grades 1, 2, 4, and six were randomly selected and assigned to different treatment groups. Results showed that students in sixth grade were more skillful in observation and comparison using solid objects than photographs. Students in second grade performed better on observation and comparison tasks using photographs. Students in grades four and six were more skillful on observation and comparison after using solid objects than with drawings. Fourth graders were more successful after using drawings than photographs.

This study suggests that there may be differences in effectiveness of three dimensional models due to maturation, though it is not clear why this should be the case.

Snyder (1976) did a study on student preferences for film or demonstration. 32 nonscience students in an undergraduate physics course were surveyed following treatment over a semester by demonstration and films. Responses indicated tolerance of amateur live demonstrations and a negative attitude toward film. Snyder concluded that live demonstration provides person to person contact, immediate feedback and clarification.

The planetarium might also be considered a three dimensional model reducing large spacial relationships and time frames to a more convenient and manipulative size.

> Burnette (1976) investigated the use of the planetarium in changing attitudes and achievement in earth/space science instruction. Fourth, seventh and eighth grade students participated in the study which used a local planetarium as part of the course work. Students were tested after completing a one year conventional course without the planetarium experience. These were used as the comparison group. The treatment group also completed a one year science course but included one or more planetarium visits. Fourth grade students demonstrated a moderate improvement in attitude toward science. Junior high students indicated improvement in both affective and cognitive measures. Eighth graders showed significantly higher achievement.

This study is of questionable quality. There are far too many intervening variables not controlled in the study to demonstrate a causal relationship between the few planetarium visits and the outcomes described. However, it does suggest that the area is worth pursuing in more controlled research.

FIELD TRIPS AND MUSEUMS

Related to the studies on use of planetariums is the research on out-of-door field trips and museums. Field trips are amenable to the same type of media analysis as any other instructional mode. Three categories need to be considered the nature of the display, the response or outcome desired, and the available feedback. Koran and Baker (1979) have reviewed the research on field trips and museums and conclude that field trips do not usually exceed classroom learning on measures of knowledge gained or content learned. Thus, there is not compelling support for field trips over conventional classroom instruction, however, the major justification for field trips should be unique outcomes that arise such as interest, motivation, and even rejuvenation for teachers. Further, field trips should be used if they meet the desired objective or outcome with the teacher designing the field trip in such a way as to achieve the desired result. As with other instructional techniques field trips should only be used with adequate preparation and follow-up. Similar findings and recommendations were used for the specific field trip to a museum.

Bennett (1963) compared field trips with classroom instruction in seventh grade. Five teachers were involved in the study using their seventh grade classes which were grouped by reading ability. The 105 students were divided into two groups. A unit of study was employed over a two week period. One group studied the ecology unit by field trips, the other by conventional classroom instruction. There were no significant differences between groups on achievement. The author concluded that either mode of instruction could be used to teach the desired content to seventh grade students.

Glenn (1968) investigated the effectiveness of two different methods of presenting field trip experiences in developing student ability to make observations and to form hypotheses. One treatment group received the conventional geology course supplemented with four teacher conducted field trips. A second group students stayed in the classroom and were shown slides of field trip experiences. A third group not taking the course was used as a control. Results indicated that the group taught in the classroom with slides scored significantly higher than the control on ability to form hypotheses, but did not score significantly different than the field trip group. Both treatment groups were able to demonstrate significantly better observation abilities than the control.

Wise (1970) compared field trips with indoor learning in elementary school. Three different approaches were used in a three week study with fifth graders. 261 students were randomly assigned to treatment groups. Direct experience, outdoor classroom, and indoor classroom were the designated treatments. There were no significant differences among the treatment groups on either posttest or retention tests of science knowledge. Neither were there any significant differences on science comprehension.

McNamara (1971) compared learning behaviors of eighth and ninth grade ESCP students in laboratory investigations and in field experiences. The indoor group had one unit of the ESCP course in the classroom The outdoor group had all phases of the unit that the laboratory investigations were conducted out-of-doors. There were a total of 15 groups and six teachers. Learning in the out-of-doors was enhanced when concepts were related to the environment. Critical thinking and preference for out-of-doors were changed favorably as a result of treatment.

Hosley (1974) compared field experience with three screen slide tape presentation with 400 fifth graders assigned to 4 treatment groups. Group 1 received no treatment. Group 2 received the slide presentation. Group 3 went of field trips and group 4 had both slides and field experience. Results indicated that students viewing the slides scored significantly higher than those receiving no instruction and as well as those going on the field trips. The combination of treatments produced the highest scores.

Brown and Ladd (1974) initiated an audiovisual program designed to simulate a field trip for students in an introductory geology course at Boston College. The program consisted of 12 weekly exercises combining filmstrips, slides, and audio tapes and one lecture a week. 50 students selected at random from those registered for the course participated in the study. Both the experimental and the control students did equally well in course achievement. The simulation group demonstrated such enthusiasm for the program that it was extended to all students taking the course.

Hickman (1976) conducted a survey of teachers in Oklahoma on their use of field trips. The 202 responding teachers indicated that those who used field trips considered them to be worthwhile as a means of instruction. Teachers used field trips when given adequate finances and opportunity. Teachers take students on field trips to facilitate gaining of knowledge and to arouse interest. Teachers have taught themselves how to use field trips. College preparation has been inadequate to ensure that field trips are incorporated into the science program. School policies are generally favorable to field trips, but administration through procedures and practice effectively limit field trips.

Gilbert (1962) investigated the value of the guided museum tour as a resource for acquiring knowledge in certain aspects of high school biology and for generating interest in biology. One-hundred-twelve students took part in museum visits as part of their biology instruction. One-hundred-five students did not make these trips but studied the same subject matter. Pre- and posttests were administered. Questionnaires were also prepared. The Nelson Biology Test showed no significant differences between the achievement of the two groups. The criterion referenced test which was administered showed significant differences favoring the museum group. Students favored the museum visits. Teachers agreed that the objectives of the museum tours were satisfied and had been valuable.

These studies further support the findings of Koran and Baker (1979). The findings of research on excursions is that they are important instructional adjuncts when carefully analyzed and constructed and employed for appropriate outcomes. Teachers must ask themselves if the field trip at the point in their instructional sequence will produce the desired outcomes for their students. The research reviewed suggests that the teacher become completely familiar with the site, that advance instruction be provided as to what will be experienced on the field trip, that focusing student attention on the objectives of the field trip is critical, and that follow-up activities be provided after the field experience.

SUMMARY

This chapter has reviewed the research on visuals including pictures, graphics, three dimensional models, overhead transparencies, and field trips. Comparison studies on the use of visual versus other modes of instruction show that as with other media visuals are as effective as conventional modes of instruction. Koechel (1970) and Dwyer (1973) have shown that visuals are not always effective and may be more effective for some subject areas and some students than for others.

This is further supported by Well et.al. (1973). Janoscrat (1976), Dwyer (1976), and Fuller (1977) demonstrated that visual instruction is just as effective in effecting student achievement as other means of instruction.

Studies on pictorials have shown that quality pictorials can aid in increasing studnet achievement (Weisberg 1969; Voelder 1973), however Wardle (1975) and Thomas (1977) indicate that color is not a significant addition to effectiveness of pictorials unless the color is used to identify and focus student attention on particular parts of objects. This is supported by Dwyer (1968), Holliday (1975) and Berry (1975). Further, Dwyer (1976), Holliday and Dahl (1976) and Tarcza (1976) have shown that not only is color not a significant contributor but that at least for science simple, black and white drawings are generally most effective. Moore and Sasse (1971) showed differential effects due to the size of pictures projected as slides, but this is contradicted by Dwyer (1976) for printed materials.

Goldberg (1965), DeVito (1966), Barufaldi and Dietz (1975), and Burnette (1976) also demonstrated significantly greater achievement effects using three dimensional models compared with description, drawings, or photographs. Models are particularly useful to help students develop spatial relationship skills (Dunstone 1972).

Koran and Baker (1979) succinctly summarized the research on field trips. There is no compelling support for field trips in regard to increased achievement, however, they tend to be popular and commonly used. Field trips are important instructional adjuncts and are most effective in affecting other student outcomes such as interest, motivation, and perhaps even applications of classroom learnings.

CONCLUSION

Visuals are effective means of communication. The choice of the particular type visual or any other media to optimize learning is crucial. What is clear from the overview of research on educational communications technology is that no one media is best. What is best is a careful selection of the appropriate media to fit and accomplish the desired learning outcome. This selection is dependent on both subject matter to be conveyed and on the age and ability level of students to be addressed. Teachers need help in learning how to make this selection. Even more they need additional training either preservice or inservice to be prepared to use the various media. Most now learn this on their own or do not use the media they are unfamiliar with thus effectively reducing the potential for selecting the right media for the job.

For science instruction at the intermediate school level line drawings are more effective than color photographs. Yet text publishers go to great expense to provide colorful instructional materials in the belief that these are more attractive to students and thus more motivating. This belief is not supported by the research. What is more likely is that these colorful pictorials appeal to those adults to select and purchase books. The rationale for use is thus for something other than student acheivement gains.

Even though the literature on field trip effectiveness is not definitive, both teachers and students extol the positive virtues of such experiences beyond what one would expect given the results of research at this time. This suggests that beneficial effects of field trips may not have been explored or measured as yet.

As with all instruction teachers should prepare students, conduct the learning experience, and follow it up with adequate reinforcement so that students can optimize each learning situation. ETV, film, audio, programmed learning, and visuals are all effective means of instruction. Each has unique contributions it can make and limitations on its use. The trick is to select the right one at the right time with the right audience.

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